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FIFTY-THIRD ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

PART I.

REPORT OF THE PRESIDENT AND OTHER OFFICERS OF ADMINISTRATION

FOR FISCAL YEAR ENDED NOV. 30, 1915.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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Approved by
The State Board of Publication.

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The Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Dec. 1, 1915.

To His Excellency DAVID I. WALSH.

SIR: — On behalf of the trustees of the Massachusetts Agricultural College I have the honor to transmit herewith, to Your Excellency and the Honorable Council, Part I. of the fifty-third annual report of the trustees, for the fiscal year ended Nov. 30, 1915, this being the report of the president of the college and other officers of administration to the corporation.

I am, very respectfully, your obedient servant,

KENYON L. BUTTERFIELD,
President.

REPORT OF THE PRESIDENT OF THE COLLEGE.

Gentlemen of the Corporation.

I herewith submit my annual report as president of the Massachusetts Agricultural College, and with it transmit reports from the other administrative officers of the institution.

GENERAL REVIEW OF THE YEAR.

Marquis F. Dickinson.

Mr. Marquis F. Dickinson died at his home at Marks Meadow, Amherst, Sept. 18, 1915. From 1905 to 1913 Mr. Dickinson was a member of our Board of Trustees; he served continuously on the important committees of buildings and grounds and of course of study and faculty; from 1907 to 1912 he was chairman of the former. The following tribute was adopted by the trustees, and spread upon their records, at a meeting held Oct. 30, 1915: —

> Marquis Fayette Dickinson was a member of this Board from 1905 to 1913, succeeding to the vacancy caused by the resignation of Charles L. Flint. His appointment by Governor Bates was a surprise to many, and was criticized by a number of practical farmers, who thought at the time that a practical farmer instead of a lawyer should be appointed to the Board. The appointment proved a wise one, for we needed a man of Mr. Dickinson's training and temperament. We needed a lawyer to advise us in legal matters. Mr. Dickinson's services were invaluable in this respect.
>
> But, aside from legal advice, Mr. Dickinson was a wise counsellor and a genial associate. His keen humor and happy suggestions often relieved a tense moment in our discussions. He possessed a charming personality, always sunny, buoyant and optimistic. He took a broad, hopeful view of life, and of the work of this institution. While Amherst College was his alma mater, yet he loved "Aggie" as much as he did Amherst, for it touched him to have been made one of its trustees.
>
> He was a loyal friend of the college and of those who came to know him intimately. We regret that ill health compelled him to resign, but he left a delightful memory and a splendid example of faithful, cheerful, helpful service. This Board wishes to record its deep appreciation of that service, and to extend to his family its sincere sympathy.

Changes in Trustees.

About a year ago Mr. George P. O'Donnell of Northampton resigned from the Board of Trustees. Although a member less than two years he rendered able and helpful service. His successor, Mr. John F. Gannon, is assistant superintendent of schools in Worcester, and brings a knowledge and experience which have already proved of great value.

Resignation of Prof. J. Allan McLean.

The resignation of Prof. J. A. McLean was accepted to take effect September 30. Professor McLean was head of the Department of Animal Husbandry for four and one-half years, and during that time became an influential leader in stimulating interest in the live-stock industry of Massachusetts. Under his direction the animal husbandry work of the college was greatly improved. He developed a series of courses fully equipping young men to engage in the animal husbandry industry, or to become teachers, investigators or Extension Service workers in this field. He encouraged competitions in live-stock judging among the students, and the teams representing this college repeatedly won distinction in stock-judging contests in New England and at the International Dairy Show at Chicago. The live-stock equipment of the college was, under Professor McLean's direction, greatly amplified.

Retirement of Capt. George C. Martin.

In January, 1915, Capt. George C. Martin, U. S. A., retired, was relieved of his duties as commandant and professor of military science and tactics at this institution. Captain Martin was first detailed to this post in September, 1905; in 1909, when his first detail expired, he was, at the request of the president, detailed for another period of four years; when his second term expired it was impossible to secure the detail of Lieut. Henry W. Fleet, the army officer whom we had selected for the work here. It was not until this last winter that the appointment of Lieutenant Fleet was made, and accordingly Captain Martin continued to serve as commandant until that time. The trustees' committee on course of study and faculty, at a meeting held on Feb. 5, 1915, adopted the following resolutions with respect to Captain Martin's service: —

> *Whereas,* For nearly ten consecutive years Capt. George C. Martin, U. S. A., retired, has rendered faithful and efficient service as head of the Department of Military Science at the Massachusetts Agricultural College; and
>
> *Whereas,* During this period he has elevated the work of the department to a high plane of efficiency; and
>
> *Whereas,* He has ever enjoyed the respect and admiration of students and faculty associates; be it
>
> *Resolved,* That the trustees do hereby formally express their appreciation of and gratitude for the service thus rendered.

I wish to add a word of deep personal appreciation of Captain Martin's services to his department and loyalty to the full range of interests of the college.

PROF. RICHARD H. FERGUSON.

Richard Hay Ferguson, extension professor of Agricultural Economics since Jan. 1, 1914, died Dec. 1, 1915, after an illness of three months. He was a native of Belfast, Ire., but had spent most of his life in New Zealand, where he was graduated from Canterbury College at Christ Church. Coming to America in 1911 he completed the course at the Agricultural College, Guelph, Can., since which time he has been engaged in educational work. Having been in close touch with agricultural co-operation in New Zealand, he was well fitted to take up the extension work in co-operation and marketing. He was a tireless worker, and nearly twenty farmers' co-operative associations organized in Massachusetts since he came to the college testify to the success of his work. He made also a study of the methods and costs of milk distribution in Massachusetts, probably the most careful and complete that has been anywhere attempted. Mr. Ferguson was a man of wide interests, a thorough student, a loyal friend, a most valuable man. His service in making the beginnings of a business organization of Massachusetts farmers marks a new epoch in the agricultural history of the Commonwealth.

New Professorial Appointments.

On the retirement of Captain Martin the War Department detailed Lieut. Henry W. Fleet as commandant. Lieutenant Fleet was educated at the Culver Military Academy and at the University of Virginia. He has been a commissioned officer in the United States army since 1902, and just previous to his detail here served with his regiment in the southwest and in Mexico. It is evident that under Lieutenant Fleet the work in military science will be conducted on the same high plane of efficiency established by Captain Martin.

Orville A. Jamison was elected to the newly created position of assistant professor of dairying. Professor Jamison is a graduate of the Ohio State University, and has had three years of successful experience as a teacher at the Michigan Agricultural College and at the University of Maine.

Earl Jones succeeds Prof. E. M. McDonald, who resigned in February, 1915, from the position of assistant professor of agronomy. Professor Jones is a graduate of the Ohio State University, and received his degree of master of science from that institution in 1913. For two years he served as instructor in agronomy at the University of Maine.

John C. McNutt has been elected to succeed Prof. J. A. McLean as head of the Department of Animal Husbandry, and will assume his duties Jan. 1, 1916. Professor McNutt was born and reared on a farm in Ohio, and received his academic training at the Ohio State University. For two years he taught animal husbandry at the New Hampshire State College, and for the past four years has been professor of animal husbandry at the North Carolina College of Agriculture and Mechanic Arts. While in college Mr. McNutt specialized in animal husbandry, and on various occasions won distinction as a judge of live stock. While in New Hampshire he was particularly successful in training student stock-judging teams, and this has been followed by conspicuous success at North Carolina.

John Phelan was elected head of the Department of Rural Sociology to succeed Prof. E. K. Eyerly, whose resignation took effect Aug. 31, 1914. Professor Phelan was educated at the

Western State Normal School at Kalamazoo, Mich., and at the University of Michigan. He taught for several years in rural schools in the west. For two years he was director of the rural school department at the Western State Normal School, and for the past two years has held a similar position at the Stevens Point, Wis., normal school. Professor Phelan is well fitted by training and experience to develop our work in rural sociology in a satisfactory manner, and he has entered into the work with enthusiasm and skill.

Charles H. Thompson was chosen to fill the newly created position of assistant professor of horticulture. Professor Thompson was educated at the Kansas State Agricultural College, and for nearly twenty years was associated with the Missouri Botanic Gardens at St. Louis as teacher and research worker along horticultural lines. Professor Thompson will teach various courses in plant propagation and plant materials, thus relieving instructors whose primary work is along different lines.

Andrew S. Thomson takes the new position of assistant professor of market gardening. Professor Thomson is a graduate of Brown University, and has pursued graduate work at Columbia University. He has had a long and successful experience as a teacher and superintendent of schools. For three years he has been at the head of the department of agriculture at the Clarion, Pa., normal school.

Harold F. Tompson was secured to serve as head of the Department of Market Gardening. He will, however, devote most of his time to extension work among the market gardeners in the vicinity of Boston. Professor Tompson was graduated at this institution in 1905, and has had a very successful experience as a practical market gardener in the southeastern part of Massachusetts. From time to time he has also taught with marked success.

Sumner R. Parker, during the closing days of the year, was elected to a position in the Extension Service, which gives him the government title of assistant State leader. He will take the place of Mr. Benjamin W. Ellis, who has resigned to enter practical work. Mr. Parker's employment will begin Dec. 6, 1915. Mr. Parker is a graduate of this institution of the class of 1904, and was for many years manager of the Mixter Farm at Hardwick, Mass. For nearly a year he has been agricultural adviser for the Franklin County Farm Bureau. His work will be that of organizing the farm bureau work in this State.

ATTENDANCE.

The total enrollment of students in work of college grade exceeds that of a year ago by 58, or 9½ per cent. This increase is due almost entirely to the freshman class, which this fall has a registration of 211, as compared with 168 of a year ago. This is the largest entering class which we have ever had, exceeding that of 1913 by 9. The number is probably not so great, however, as it would have been had we had a normal increase in the size of the class entering in 1914. It should be noted that the present sophomore class has now an enrollment of 162, whereas its initial enrollment as freshmen was only 168. Usually a very much larger percentage of the class fail to meet our scholarship requirements for the first year. Attention should be called to the fact that 9 young women entered with the freshman class this fall; the total number of women students in regular attendance is now 18. (See Table V. for analysis of the enrollment.)

SHORT COURSES.

The usual winter and summer schools, together with their accompanying conferences, have been conducted this year with continued success. The enrollment in the winter school was 182, the same number as were present in 1914. On account of the prevalence in the State of the hoof and mouth disease it was deemed advisable to cancel the annual farmers' week, the school for tree wardens and the Polish farmers' day. The summer school of agriculture and country life had an enrollment of 162, this number being about 10 per cent. greater than in 1914. The school for rural social service, the school for library workers and the poultry convention were all well attended, as was also the conference on rural community planning. The demand for boys' agricultural camps has grown to such an extent that this year we were obliged to conduct three camps, the total enrollment being 92. This year, for the first time, we opened a camp for country girls, the attendance being 13. (See Table V. for complete statistics of attendance at these schools and conferences.)

COMMENCEMENT.

The annual Commencement Day exercises were held Wednesday, June 16. For the first time in the history of the college the number of graduates reached and exceeded 100. The degree of bachelor of science was conferred on 100 men and 1 woman; the degree of master of science was conferred on 5 candidates; and the degree of doctor of philosophy on 5. The alumni dinner was attended by 241 alumni and officers of the college. Hon. Carl S. Vrooman, assistant secretary of the United States Department of Agriculture, delivered the Commencement address, his subject being "The Farmer of the Future."

CELEBRATION OF THE FIFTIETH ANNIVERSARY OF THE COLLEGE IN 1917.

Oct. 2, 1917, will mark the fiftieth anniversary of the opening of the college to students. It is planned to have at about this time an appropriate celebration of the event. A faculty committee is already at work on plans for celebrating this anniversary, and the details of the program will be announced at a later date. It is probable that a pageant, covering the history of New England agriculture, will be a prominent feature.

PANAMA-PACIFIC EXPOSITION.

The college prepared for the Panama-Pacific Exposition a display of horticultural appliances and methods; also an exhibit covering the work in rural social science. This exhibit was a part of the general agricultural exhibit prepared by the United States Department of Agriculture, which exhibit was awarded a gold medal.

THE FOUR-TERM PLAN AND SUMMER WORK.

During the past year the faculty has developed a project which has been approved by the trustees, whereby the college year will be divided into four terms or quarters, thus offering an opportunity to arrange work for college credit during the summer months. This appears to be a distinctly progressive movement whereby the college plant, or such parts of it as can be utilized to advantage during the summer, will be used in the more adequate training of our students. It is expected, also, that by dividing the present college year into three terms instead of into two semesters better instruction can be given. It has been found that the task of readjusting our present curriculum to the new proposed plan is one of considerable magnitude. Accordingly, the new schedule will not be ready for operation until the fall of 1916.

Nonathletic Student Activities Board.

About a year ago several leaders of student activities requested that these nonathletic activities be organized in some such way as are the athletic activities. Accordingly, various conferences were held between representatives of the students and of the faculty, and as a result a Nonathletic Student Activity Board has been organized, following the plan adopted in the management of athletics. This board is composed of faculty, alumni and student representatives. Prof. H. E. Robbins has been appointed general manager of this work, and has general control and supervision over all of the student activities represented on the board; this supervision extends to all financial transactions as well as to schedules of appointments and other questions of administration and policy.

The Graduate Summer School, 1916.

For some years the Association of American Agricultural Colleges and Experiment Stations has held biennial sessions of a summer school intended to meet the requirements of persons on the agricultural staffs of the land grant colleges. The school is in session a month, the lectures being given by men prominent in their respective lines of work, both in this country and abroad. The school has convened heretofore at Ohio State University, Cornell University, the University of Illinois, Iowa State College, Michigan Agricultural College and the University of Missouri. The association, on our invitation, voted to hold the next session on our campus during the month of July, 1916; the acceptance was a compliment to the college, and the event should be of direct significance and of substantial aid in connection with our own graduate school.

County Leagues and Farm Bureaus.

Under a law passed by the Massachusetts Legislature of 1913, some nine county leagues and farm bureaus have been organized and are at work. Their organization is part of a nation-wide movement which has introduced a new and aggressive agency into the system of agricultural education.

The plan of organization of these bureaus varies in different States. In the large majority of States the "county agent" is an employee of the agricultural college and directly responsible to the college. The farm bureau is always a voluntary organization, but usually receives local public aid as well as private financial assistance. In some cases the bureau is in reality a federation of existing organizations; in others it is entirely distinct. In our own State the county agent is an employee not of the college but of the farm bureau.

The precise relation between the college and the county farm bureaus is not yet fully defined either by the law or in practice, possibly not even in theory. It is important that in the near future this relationship should be developed to a complete and satisfactory understanding. Probably under the Massachusetts law the secret of correlation is a thoroughgoing co-operative scheme which recognizes the integrity of each bureau, provides for a certain amount of both State and Federal aid, and requires approval of "projects" and of employees by the State and Federal authorities. However this may be, it is clear that the work done by the farm bureaus and leagues should be part of the State system of popular agricultural education, and in particular should fit definitely with the Extension Service of the college.

The Massachusetts Agricultural Development Committee.

In my report for 1912 (page 46) I recommended "a commission on agricultural education and organization." On vote of the trustees, supplemented by a vote of the State Board of

Agriculture, a voluntary committee was organized, consisting of the representatives of some six agencies. One meeting of this committee was held and officers chosen, but no steps were taken towards the accomplishment of results. Last winter two or three proposals were made in the Legislature for commissions on agricultural development, but none of them passed the Legislature. As a direct result, however, of the discussion of these proposals there was organized a voluntary committee, which took the name of the Massachusetts Agricultural Development Committee, and which is at present composed of the agricultural agent of the State Board of Education, the State Forester, the chairman of the executive committee of the State Grange, a representative of the County Agricultural Schools, a representative of the State Federation of Improvement Leagues and Farm Bureaus, and the president of the Massachusetts Agricultural College.

In addition to your authorization of my own service with this committee, you also granted permission to Dr. Cance and Professor Morgan to serve as agents of the committee. The committee has considered the question of providing for an adequate study of the agricultural resources of the Commonwealth, a plan, which when developed further by the committee, I hope to be able to present to your Board. The committee has also served as a clearing house for the discussion of proposed agricultural legislation. I am confident that great service has already been rendered by this committee, and expect that before long the agricultural problem in Massachusetts will have been charted, the various agencies at work will have been listed, and that we will see the beginning of fuller co-operation of all rural agencies on behalf of the maximum improvement of Massachusetts agriculture and country life.

The Massachusetts Federation for Rural Progress.

At your annual meeting in January, 1913, you authorized the college administration to take steps to call a meeting for the organization of a federation of the agricultural and country life institutions of the State. This organization was effected in the autumn of 1913, under the name of the Massachusetts Federation for Rural Progress. It was discovered that there were some twenty-five or thirty State-wide agencies, supported either at public or at private expense, interested in one phase or another of Massachusetts agriculture and country life. The federation has brought together representatives of these agencies a number of times, has held series of conferences on rural affairs, and in various other ways has made a real contribution to the ever present and significant task of organizing Massachusetts agriculture and country life.

Legislative Appropriations.

The Legislature of 1915 was requested to grant us appropriations for: (*a*) addition to the power plant, $30,000; (*b*) miscellaneous additions, $10,000; (*c*) student dormitory, $40,000; (*d*) laboratory for microbiology, $67,500. The only appropriations granted, however, were those for the laboratory for microbiology, $67,500, and a portion of our request for the addition to the power plant, $10,000. An attempt was made last winter to secure from the Legislature a continuing appropriation for buildings and other improvements; the request was for $200,000 a year for six years. The Legislature, however, declined to grant this request.

Alumni Athletic Field.

The past year has seen several important advances toward the completion of the athletic field. In June, 1915, sufficient funds had been raised to pay what was still due for grading the field, and a balance of about $700 was on hand. Plans for fencing were considered, and it was decided to erect a permanent wire fence on the north, west and south sides, leaving the east side until certain parts of the grade could be extended. This fence was completed in September at a cost of $1,900. The grounds service of the college has done considerable work in filling and in extension of grades, including the preparation of the baseball diamond; this work has cost $500. With the opening of college in September it was evident that certain portions of the field were in condition for use in football. Therefore movable bleachers capable of seating 600 people were purchased at a cost of $500.

The above statements show that approximately $3,000 has been expended upon the field this year. Of this amount about $1,500 still remains to be raised; it is hoped that this may be done before spring, so that other necessary construction may be started. The field was open for use this autumn, and its present condition is far better at this early date than was expected. It has a fine grass turf, and the surface is very firm and level. The drainage system seems to be working perfectly. The next step in the development of the field is the construction of a cinder track and tennis courts. With student assistance the running track should cost $2,000 and the tennis courts from $250 to $300 each. When these additions have been made the athletic field will be quite adequately equipped for both intercollegiate and intramural sports.

Construction, Improvements and Repairs.

This year marked an epoch in the "brick and mortar" history of the institution on account of the amount of money expended on building construction. The infirmary buildings were started in the late fall of 1914 and were completed in May of this year. The agricultural building, Stockbridge Hall, which was begun in the summer of 1914, was completed by the middle of October of this year. This project also includes a small greenhouse for the Department of Agronomy, and one wing of the shops for the Rural Engineering Department. This building is described more fully on another page. The appropriation for these two groups of buildings aggregated $225,000. The Legislature of 1915 granted an appropriation for improvements at the power plant, $10,000, and for a laboratory for microbiology, $67,500. The latter building was started in the early part of August and is well under way; the contract calls for the completion in March, 1916. With a legislative appropriation of $10,000 for improvements at the power plant, in lieu of the $30,000 in the original, the boiler room was enlarged and one new 200 horse-power boiler installed.

A number of minor improvements have been made, such as the resetting of two of the old boilers at the power plant, extending the cinder walk from the east experiment station to the

INFIRMARY BUILDINGS, COMPLETED IN 1915.

walk leading to the college ravine, constructing an incubator cellar for the Poultry Department and a small fumigating house for hospital work. Among the repairs might be noted the painting of the entomology building and the greenhouse range, and a number of small repairs at the sheep, young stock and quarantine barns.

The Infirmary.

The Legislature of 1913 appropriated $15,000 for the construction and the equipment of a student infirmary. Some delay was experienced in perfecting plans for this infirmary, and the building was accordingly not completed until the spring of 1915, and was opened for occupancy at the beginning of the present college year. It was found that the appropriation of $15,000 was not adequate to construct a hospital of sufficient size to accommodate the students now in attendance at this institution. It was decided, therefore, to construct two cottages, which may be easily converted into isolation hospitals solely, should the general hospital be constructed later. In order to accommodate the resident nurse in the present equipment, apartments were added to one of the cottages. This plan precludes the introduction of a surgical operating room and other features in connection with a general hospital, such as laundry, emergency ward and other conveniences. The present scheme, therefore, is incomplete, inconvenient in many ways, and in some respects not wholly satisfactory. But on the other hand, it enables the institution to make a beginning in caring for its sick students, and meets in a fair way a very real need. It is hoped that funds may become available in the near future to complete the original plan for a general hospital building, and to add other isolation cottages.

A resident nurse now has charge of the hospital. A nominal charge is made to those students going to the infirmary for permanent treatment. The individual also is obliged to pay his own doctor's bills and for special nurses which may be required; also for special medicine supplies and laundry. No charge is made to students going to the infirmary for incidental treatment. The officials encourage students to go to the infirmary in case of illness or accidents, the purpose being to improve the general health of the student body by treating illness in the incipient stage. A brief summary of the number of cases treated at the hospital since college opened in September is found in Table X.

STOCKBRIDGE HALL.

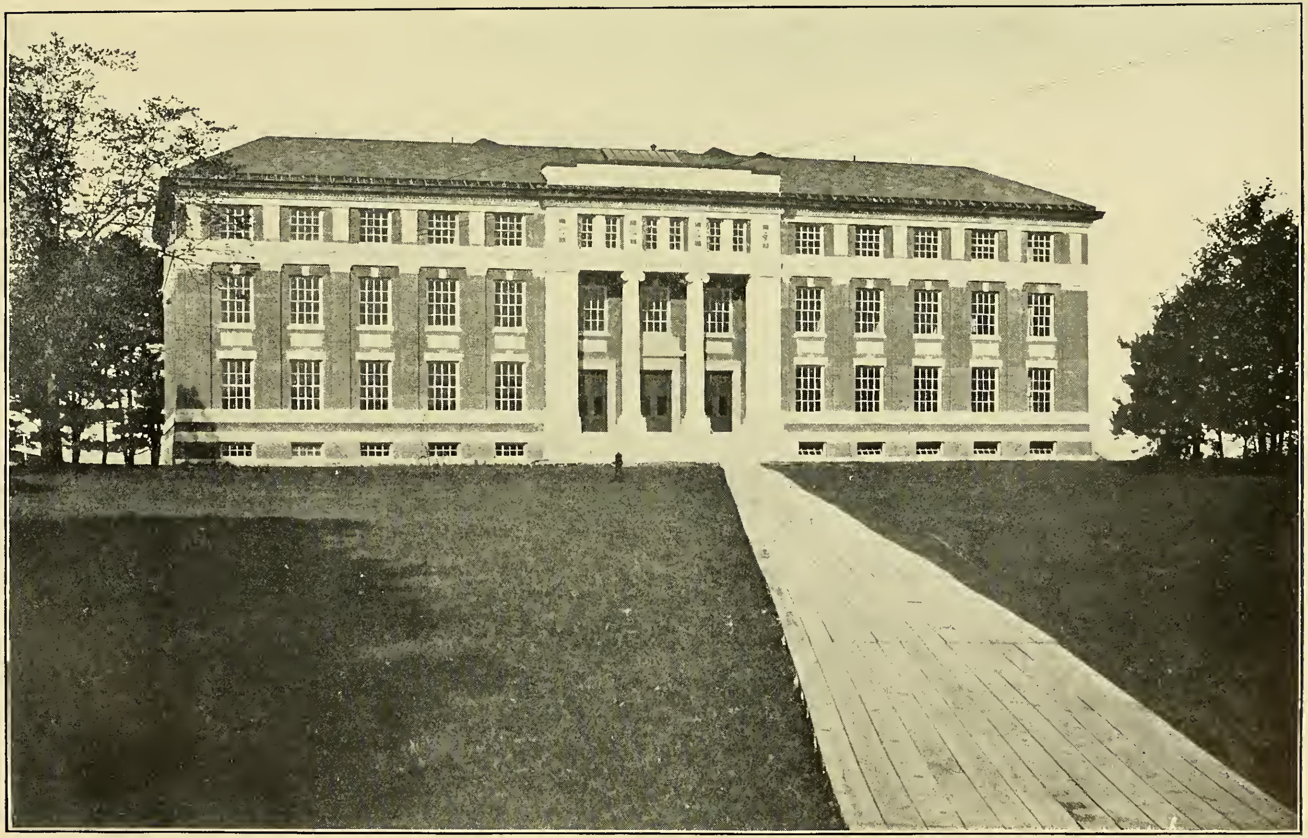
The new agricultural building, Stockbridge Hall, which was dedicated October 29, is well fitted for the purposes for which it was designed. The building is built of brick trimmed with limestone; the floors and interior supports are of reinforced concrete and steel, well protected. While this makes a permanent structure fireproof throughout, the fact that the interior walls on the three main floors are of gypsum block, allows the possibility of quite radical changes in the room arrangement without prohibitive expense, provided future needs make changes necessary. The interior finish is oak, and the lighting of the main building is semi-indirect. The building has a frontage of 166 feet and a depth of 60 feet. There are three floors and a basement available for college purposes. A private branch exchange telephone system has been installed, connecting the different offices in the building as well as the other offices in the Division of Agriculture.

The building will furnish laboratories, classrooms and offices for the Departments of Agronomy, Animal Husbandry, Farm Administration, Poultry Husbandry and Rural Engineering.

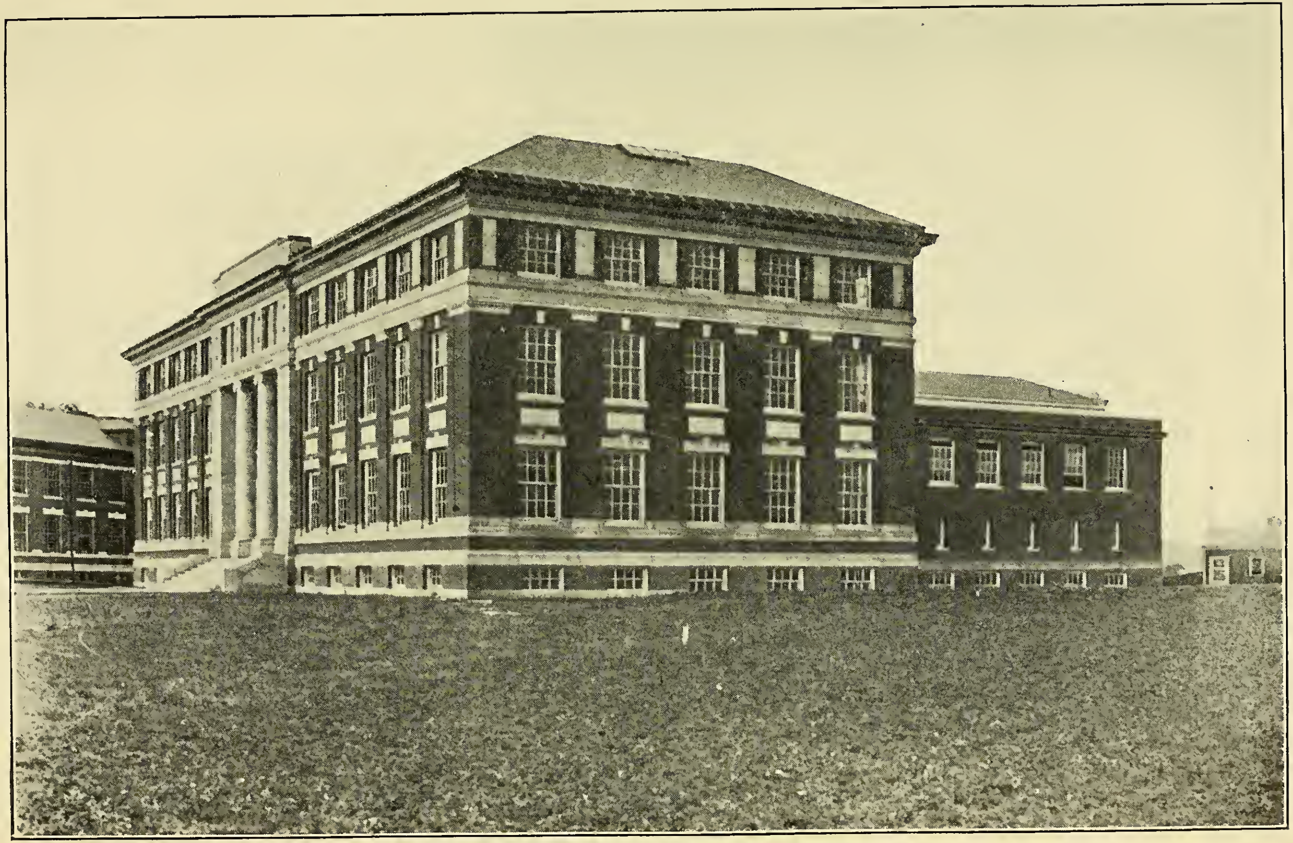
There are two large soil laboratories in the basement with stock rooms, balance rooms and a centrifuge room. A large laboratory for the use of the Department of Rural Engineering, as well as a lecture room and several storerooms, is also arranged for in the basement.

On the first floor there are five classrooms in addition to coat rooms and the offices of the Departments of Agronomy and Farm Administration.

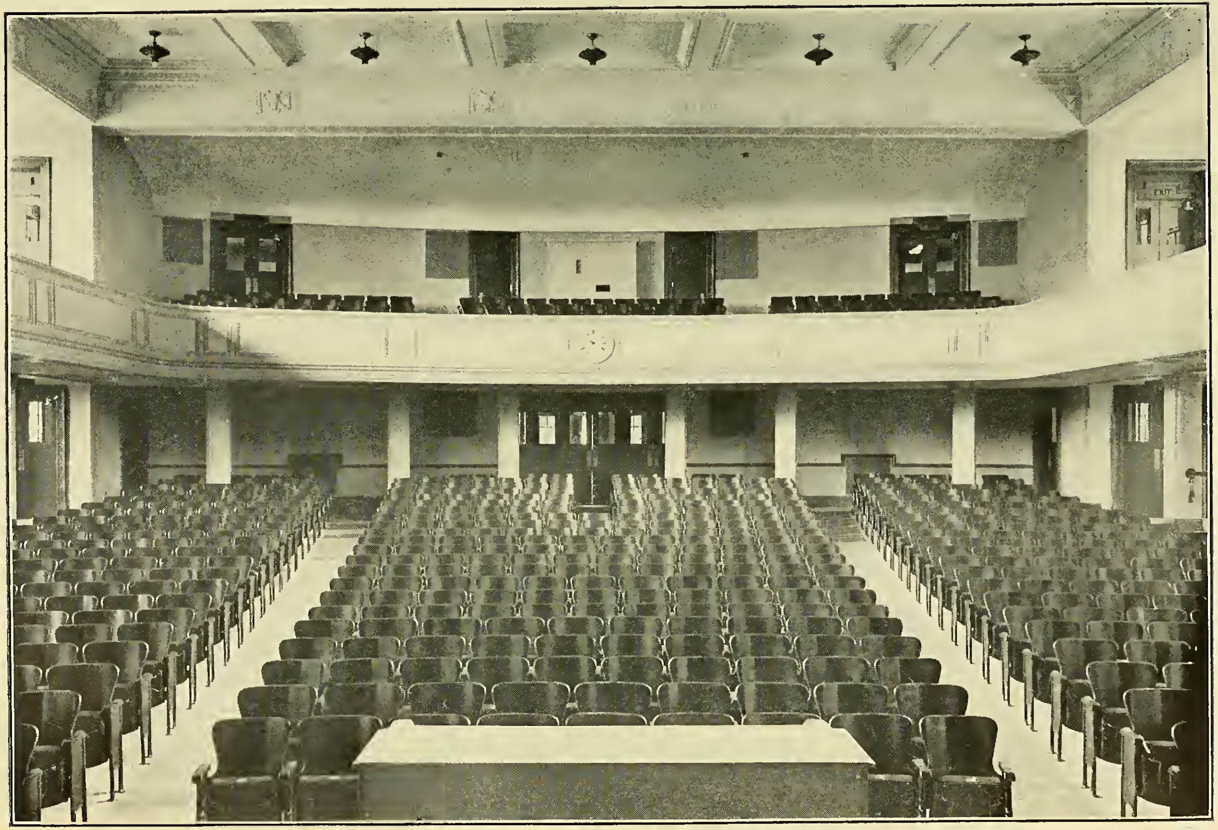
On the second floor there are two large field crop laboratories, one at each end of the building, each laboratory having light on three sides. The second floor also contains the division library and reading room and the offices of the Departments of Animal Husbandry and Poultry Husbandry, as well as balance rooms and stock rooms.



STOCKBRIDGE HALL, COMPLETED IN 1915.



STOCKBRIDGE HALL, COMPLETED IN 1915.



AUDITORIUM, STOCKBRIDGE HALL.

On the third floor there are two large laboratories for student work in poultry husbandry, as well as suitable facilities for research work. There is also a large drafting room for the Department of Rural Engineering, a museum, and some office room that is being used temporarily by the Departments of Agricultural Education, English and Rural Journalism.

The attic contains rooms for the student janitors, and a large, well-lighted mouse-proof compartment for the storage of all kinds of grain and other plant material for class work.

An auditorium, 96 by 76 feet, is connected with the main building and seats 1,000 people. An ample stage is provided with curtain and footlights. A beautiful organ has been installed. A feature of the room is a motion-picture machine, the latter being included in the equipment, owing to its growing use in educational work.

Stockbridge Hall is our latest and best building. It represents the most modern ideas in regard to classrooms, offices and laboratories. No room is wasted. It is a substantial and beautiful building. It should be of service to the college literally for hundreds of years. It is probably the largest and most complete building of its kind in New England, and one of the best in this country.

Stockbridge Hall was formally dedicated Oct. 29, 1915. The following program was held in the afternoon, and in the evening the organ in the auditorium was dedicated by Prof. William C. Hammond of Holyoke, assisted by Miss Ada Chadwick of Mount Holyoke College. On October 2 the new auditorium was informally dedicated by the students and faculty, at which time the students gave a program of music and drama.

DEDICATION OF STOCKBRIDGE HALL, FRIDAY, OCT. 29, 1915.

Program.

"Tancred Overture," . . . . Rossini.
COLLEGE ORCHESTRA.

Prayer.
EDWARD M. LEWIS, Dean of the College.

"Levi Stockbridge and Charles L. Flint."
WILLIAM H. BOWKER, M. A. C., '71, Chairman of Trustees' Committee on Buildings and Grounds.

"Agricultural Possibilities in New England."
JOSEPH L. HILLS, M. A. C., '81, Dean, College of Agriculture, University of Vermont.

"Ballet Egyptien," . . . . A. Luigini.

I. Allegro non troppo.
II. Allegretto.
III. Andante sostenuto.
IV. Andante exprissive.

COLLEGE ORCHESTRA.

"The Engineer in Agriculture."
WILFRID WHEELER, Secretary of the State Board of Agriculture.

"The Stone which the Builders rejected."
Pres. KENYON L. BUTTERFIELD.

Beginning on page 9 of this report will be found the following tables and statistics: —

Table I. New Appointments.
Table II. Resignations.
Table III. Change in Title of Officers of the Institution.
Table IV. Speakers for the Year.
Table V. Attendance.
Table VI. Legislative Budget, 1915.
Table VII. Statistics of the Freshman Class.
Table VIII. Entrance Statistics of the Freshman Class.
Table IX. Official Visits by Outside Organizations.
Table X. Statistics of Patients at the Infirmary.

THE IMMEDIATE NEEDS OF THE COLLEGE.

The Legislative Budget for 1916.

Your Board has already voted the following budget for presentation to the incoming Legislature: —

Completion of power plant,	$35,000 00
Library,	230,000 00
Completion of rural engineering shops,	12,000 00
Student dormitory,	40,000 00
Miscellaneous improvements and new equipment,	60,000 00
Extra labor on account of Saturday half holiday,	5,000 00
	$382,000 00

The following is a brief statement of the need for the appropriations as listed: —

Addition to the Power Plant, $35,000.

Our request of a year ago was for an appropriation of $30,000 to enlarge and further equip the power plant. The Legislature made a grant of $10,000 for this purpose. With this money it was possible to extend the boiler room and to install one new 200 horse-power boiler. But new buildings mean new demands on both heat and light. The electrical load is a little over 400 kilowatts; the generators are rated at 150 kilowatts. It is imperative, therefore, that we increase our electrical equipment as soon as possible. To do this it will be necessary to build a building 40 by 60 feet, directly north of the boiler room, with full equipment. One new boiler should be added as a reserve. These improvements will cost $35,000, the details being as follows: —

One 40 by 50 foot brick building,	$10,000 00
One 300 kilowatt generator and turbine,	7,800 00
One switchboard,	2,000 00
Piping and labor for installing electrical equipment,	2,500 00
One 200 horse-power boiler,	4,000 00
Retaining wall and platform for coal pocket,	4,200 00
One chimney,	4,500 00
	$35,000 00

Library Building, $230,000.

In 1902 the late President H. H. Goodell, in submitting his annual report to the trustees, said: —

> Our library building is full to overflowing, and those books not in active circulation are being withdrawn and piled upon the floor or on the top of the cases. . . . It now numbers 23,681 volumes. . . . A new building properly equipped cannot be long delayed.

At the time that President Goodell wrote, the enrollment of regular students was 180; the enrollment of winter-course students 16; making a total maximum of 196 students who used the library.

Again, in 1903, President Goodell wrote: —

> The library has entirely outgrown its building. Twenty-eight hundred volumes have been withdrawn from circulation. . . . Another building, fireproof, with stackroom and all the adjuncts that add so much to the serviceableness of a modern library, is imperatively demanded.

At this time the enrollment of four-year men was 185; of winter-course students 28; making a total of 203 students who used the library.

At a time when there were less than 25,000 volumes in the library, and only 200 students, there was a strong feeling on the part of the administration that a new library building was needed. How much more is a new building needed when, after the lapse of thirteen years, we still have almost the same library facilities, but with nearly 50,000 volumes, or twice the number of books, and with 850 students, or over four times as many students.

The librarian, who has gone to the limit of his patience, suggests that the climbing of stepladders, the search for an unoccupied chair, and the squirming through crowded aisles necessarily detract greatly from serious study. It is hardly putting the case too strongly to say that we do not have respectable library accommodations. It must be remembered that the library is the vital intellectual center of college life. The library fosters every department of the college. It is a sort of hub of a wheel which securely holds every spoke; or, to change the figure, every department has its roots firmly planted in the college library. The library is the big general laboratory of the institution. It is difficult to measure the loss from poor library facilities, for there are no standards; but it requires no argument to convince even the casual visitor to our library that we are seriously handicapped at every turn because of this deplorable lack of an adequate library building.

The present plans contemplate a modern fireproof building, with facilities that can be ultimately developed to care for 200,000 volumes and an institution of 2,000 students. It is also arranged so that the structure can be considerably enlarged when, in the course of time, demands upon the library cannot be met by the building which we desire to erect now.

Rural Engineering Shop, $12,000.

The Rural Engineering Department is at present offering courses in farm structures, farm machinery and farm motors. The drafting room in Stockbridge Hall gives good accommodations for planning buildings and drawing plans, but we have no facilities for giving practical instruction in the erection of buildings. We have no means for giving even the rudimentary training in the handling of the saw, plane or hammer. Work on farm structures will lack the practical training in carpentry until we secure additional shop space and shop equipment. Laboratory work in farm machinery and farm motors is now given in three buildings, namely, Stockbridge Hall, Flint Laboratory and the rural engineering building. This has been found necessary from the fact that not one of the rooms available is large enough or suitable to accommodate all the equipment. The class work cannot be carried on most advantageously under these conditions. The situation will be improved only when we secure the addition called for in this project.

Student Dormitory, $40,000.

For six years in succession your Board has asked the Legislature for an appropriation with which to build a dormitory. I took occasion in my report last year to present this matter as definitely and cogently as possible. I can do no more now than to reiterate the arguments that have been made repeatedly. I still feel, as I judge your Board feels, that this is an important need. I am very sure that if the students were asked to vote on the greatest need of the institution at this time from the standpoint of physical plant, there would be a great majority in favor of a dormitory system. The matter is getting serious, and I hope the Legislature may see its way to an appropriation for this purpose.

Miscellaneous Improvements and Equipment, $60,000.

This sum is needed to make it possible for us to undertake certain projects of improvements on the campus, such, for example, as the construction of suitable walks and roads and minor changes in buildings, in order to bring the present facilities up to the growing demands made upon them. New equipment is needed to meet the increased demands made upon the institution by the larger attendance. Old equipment also is to be replaced. A list of some 50 separate projects for improvement, and of 75 projects for equipment have been approved by your committee on buildings and grounds. It must be remembered that for two successive years the Legislature has made inadequate provision for these developments; needs, therefore, have been accumulating.

Extra Labor on Account of Saturday Half Holiday, $5,000.

Chapter 288 of the General Acts of 1915 provided that the provisions of chapter 688 of the Acts of 1914 and amendments thereof, relative to making Saturday afternoon a half holiday for laborers, workmen and mechanics, shall apply to the Massachusetts Agricultural College. This act took effect May 27, 1915. The cost of labor for the year 1914 was approximately $50,000. Since that time two new groups of buildings have been added to our campus. It is safe to estimate that the additional cost of labor will be in the neighborhood of $5,000. It will be understood that this is an extra draft upon the current resources of the institution not anticipated when the five-year appropriation was adopted two years ago.

A Five-year Appropriation for Improvements.

Two years ago the Legislature passed a law granting the college a progressively increasing appropriation for maintenance for a period of five years. At that time it was expected that a similar grant would be made for improvements, including new buildings, miscellaneous improvements and purchase of land; but that was not done. Last year the trustees asked for a six-year appropriation for this purpose. The committee on agriculture cordially approved the plan, changing it to five years. The report, however, was not agreed to by the House committee on ways and means. This year your Board has voted to ask the Legislature for a five-year appropriation of $200,000 annually, to cover new buildings, improvements, new equipment, and also for the purchase of land.

Sundry Projects for Legislative Action.

Seed Law.

The director of the experiment station, by authority of the trustees, has drafted a proposed seed law which will authorize the director of the experiment station to collect samples of seed, test them for purity and germination, and publish the results of the examination. In principle the measure is similar to that authorizing the analysis of feedstuffs, and the State will bear the expense of the work.

The agricultural awakening in Massachusetts has given rise to demands for aid from the college quite beyond the ability of the institution to supply with present resources. As a result, a number of interests are desirous of presenting to the Legislature projects for appropriations to increase at once the service of the college. In each case it has been made clear to the proposers of these projects that the college will be glad to do the work if the funds are made available, but that the existing obligations upon the institution cause the trustees to feel that they are not warranted in putting these projects into the college budget. In order that there may be a record of the attitude of the trustees, I am appending a brief statement of the trustees' action in each case.

Substation for Market-gardening Research.

The market gardeners in the vicinity of Boston have requested the assistance of the college in securing the passage of a bill appropriating funds for the establishment and maintenance of a substation for market-gardening research. The trustees have approved the plan, and have endorsed the bill, which will be introduced into the forthcoming Legislature, seeking an appropriation to be expended under the direction of the trustees of the Massachusetts Agricultural College for the purchase of real estate, and for experimental and other work on problems connected with market gardening.

Work in Poultry Husbandry.

The Massachusetts Poultry Association has asked the endorsement by the college of a bill that it proposes to introduce into the forthcoming Legislature, seeking an appropriation for further work in poultry husbandry. The trustees have approved the general idea embodied in the proposed bill, but suggested to those initiating the project that the bill be so modified as to make the trustees of the college administrators of the funds appropriated.

Boys' and Girls' Clubs.

There has been presented to the trustees for approval a proposed bill, seeking further State appropriations to be used in the more adequate supervision of boys' and girls' agricultural clubs. The trustees have approved the plan, though not assuming responsibility for introducing the bill. It is also the sense of the trustees that if the bill is passed, the money appropriated by the State for local support should go directly to towns.

The Tobacco Industry.

The tobacco growers of the Connecticut valley are about to introduce a bill into the Legislature providing for a small appropriation to carry on some special work of an experimental character in connection with their industry.

A STATE SYSTEM OF AGRICULTURAL EDUCATION.

In my report to your Board for the year 1911 I referred briefly to the need of soon considering the place of the college in a State system of agricultural education. During the past four years much progress has been made in the Commonwealth toward providing more adequate facilities for school training, as well as for dissemination work, in agriculture. New agencies have arisen. There is an increasing need of unification. The college has a profound interest in the new movements and its relationship to them. I think, therefore, that we should discuss with some care the problem thus suggested — a State system of agricultural education.

A Bit of History.

The present situation, although of recent origin, has its roots in an ancient and honorable chapter of educational history, and a brief review of this history is justified at this time. Massachusetts was one of the pioneers in the development of agricultural education.

The Massachusetts Society for the Promotion of Agriculture. — In 1792 the Legislature incorporated a society which still exists. At that date few societies of agriculture had been organized in any country, there being but two in Great Britain, and in this country only two others. The Massachusetts society was the first in America to receive legislative encouragement. The names of those who organized are the names of the most famous men of the time, — Samuel Adams, Gen. Benjamin Lincoln and others of equal prominence. The work of the society met with indifference and even ridicule on the part of many, and for the first twenty-five years of its existence it accomplished little. However, its leaders believed in its cause and they refused to give up the organization. They talked of an experimental farm, and the botanical garden at Cambridge is the result. Prizes were offered for essays on agricultural subjects, as well as premiums for actual work achieved along agricultural lines. In 1801 the society inaugurated a series of agricultural fairs at Brighton, which became famous in New England, and continued until 1830. The interest which this society aroused in agricultural matters led, in 1851, to the organization of the State Board of Agriculture.

Early Agricultural Schools. — An interest in providing schools for teaching agriculture showed itself in Massachusetts as early as 1820, when Andrew Nichols, addressing the Essex County Agricultural Society, spoke of the agitation for agricultural schools which Gov. DeWitt Clinton had inaugurated in New York. Nothing was done, however, and we find that four years later the Massachusetts Society for the Promotion of Agriculture was asked by the trustees of Dummer Academy, of Byfield, to help in the conduct of an experimental farm on lands belonging to that institution. This request the society refused because they felt that such an enterprise should be under the supervision of the State. What seems to have been the first actual effort to give agricultural instruction in the State was made at the Teachers' Seminary on Andover Hill, in 1840, when a course in scientific and practical agriculture was announced. Shortly after this, however, the institution was merged with Phillips Academy, and the agricultural feature disappeared. Just previous to 1860 Powers Institute, at Bernardston, conducted a course in agriculture and asked in vain for aid from the General Court.

The State Board of Agriculture. — Owing to the investigations made by Henry Colman into the conditions of agriculture in Massachusetts there was organized in 1851 the Central Board of Agriculture, which was intended to unite the existing local agricultural societies under one head. At a meeting of this Board in the following year they asked the Legislature to authorize the organization of a department of agriculture as one of the State offices. This act was passed, and that patron of agriculture, Charles L. Flint, became the first secretary, an office which he held for more than a quarter of a century. This Board "became the organ of the farming community," and has had a long and useful career.

The Massachusetts Agricultural College. — The first legislative effort to secure an agricultural college for Massachusetts was made in 1850, when a bill was presented to the General Court providing for the establishment of such a college and for an experimental farm. This bill passed the Senate, but was rejected by the House. At the next session of the Legislature a committee reported upon the advisability of establishing agricultural schools and colleges, but no action was taken, and the matter did not again come up until 1856. In that year several interested gentlemen secured the incorporation of the Massachusetts School of Agriculture, Marshall P. Wilder heading the list. In 1860 the charter granted to this body was transferred to a group of citizens of Springfield, who endeavored to raise $75,000 for the purpose, and would have succeeded, without doubt, if the outbreak of the civil war had not interfered with their plans. The passage of the Morrill act in 1862 made possible the establishment of the State college so long desired. In 1863 the State complied with the requirements of the grant and voted the establishment of the board of trustees for the new college, which opened its doors to students in October, 1867.

Agricultural Schools. — Agriculture as a branch of instruction in the secondary schools of the State has taken a prominent place during the last few years. The work is under the supervision of the State Board of Education. There are at present thirteen high schools of the State which give more or less extensive courses in agricultural subjects. Bristol and Essex counties have organized county agricultural schools, and Norfolk County will soon establish one. The instructors in agriculture serve their counties as agricultural advisers, some of them spending half of their time in the schoolroom and half in visiting and advising farmers. The Smith Agricultural School, in Northampton, is an endowed agricultural school, but receives public financial support.

Boys' and Girls' Agricultural Club Work. — The work among the boys and girls was begun by the Massachusetts Agricultural College in 1908, the first clubs being formed in Hampshire County, when some 500 responded to an invitation to join a potato-growing contest. So popular was the work that it was undertaken again in 1909, when the membership of the club increased to more than 1,000, although the work was still confined to Hampshire County. In the following year the invitation was extended to all boys and girls of the State, and the growing of corn was added to that of potatoes. Since that time other lines of work have been undertaken — pig clubs, poultry clubs, canning clubs, and home economics, which teach cooking, sewing and various forms of housework. The membership of the clubs to-day has reached virtually 70,000, and of the 354 cities and towns of the State, 314 have instituted some form of club work for boys and girls.

The Extension Service. — In September, 1909, extension work in connection with the Agricultural College was begun by the present director, who worked alone for some time, with an appropriation of $7,500. The staff and appropriations for the work have grown continually from that time, until to-day there are 16 members of the Extension Service faculty giving all their time to the work, and the State appropriation for extension work amounts to $50,000.

County Leagues and Bureaus. — In the winter of 1913 a group of interested business men and farmers throughout the county organized the Hampden County Improvement League. The purpose of the organization is the improvement of agriculture and country life, and it has met with great success. There are at present employed as agents of the league an agricultural adviser, a horticultural adviser, a home-making adviser and a supervisor of boys' club work. The league publishes a weekly paper which gives timely advice on agricultural matters and keeps the public informed as to the work of the league generally.

There are farm bureaus in seven other counties of the State, doing practically the same work as is accomplished by the Hampden County Improvement League.

The Situation.

It will be observed from this review that there are already in existence parts of a system of agricultural education, but we have no system. We have many important pieces of new work, but they are not adequately co-ordinated, while some parts of the field are as yet untouched. It would appear to be a piece of real statesmanship to begin the task of planning a comprehensive system of agricultural education supported at public expense; for clearly such support is one of the great obligations of the Commonwealth. It will not be possible or desirable to provide immediately for every part of a complete system, but the needs of the State may be studied and adequate plans formulated so that new projects will fit into the system ultimately desired.

It is obvious that the Massachusetts Agricultural College should be an organic part of such a system of agricultural education. It cannot and should not try to administer the system; it should be in very intimate association with the controlling factors. The college should have definite responsibility in the organization of the materials and in the formulation of the methods used in all grades of agricultural instruction, in the preparation of teachers, and in assisting to correlate the parts of the system. We cannot disguise our interest in the problem. Not only should we have a part in the plan; we ought to make some real contribution to it, and to its continuing success.

I may say in passing that I have discussed this matter with the Commissioner of Education, and while Dr. Snedden cannot in any way be made responsible for the opinions that are here expressed, I think I violate no confidence in saying that broadly speaking our views coincide.

In discussing the requirements of an adequate State system of agricultural education we may outline the problem in the following aspects: —

I. Some characteristics of a State system of agricultural education.
II. The types of work to be recognized.
III. The groups of persons to be reached.
IV. The scope of agricultural education.
V. The machinery to be invoked.
VI. Administration.
VII. A word of recommendation.

I. Some Characteristics of a State System of Agricultural Education.

1. *It should have Definiteness of Aim.* — Fundamentally, it is the province of agricultural education to help solve the rural problem. The rural problem is partly a question of securing better farm practice; partly a question of organizing better

farm business; partly a question of developing a better farm life: In a word, the rural problem consists in the improvement or progress of the rural people. Many forces may be invoked for this improvement, such as education, socialization, organization, even religion; but the problems are solved by men and women. Hence, the training of rural problem solvers is the main purpose of agricultural education.

2. *It should be Inclusive in its Human Reach.* — It will reach all ages, from the youngster in the grades to the graduate student in the college. It will provide for teaching to those out of school, both young and old. With respect to emphasis, it will serve chiefly the people who must make a living by farming; but it must also train specialists or professional experts. Nor will it neglect people of the city; many of them as well as the country folk need agriculture.

3. *It should be Broad in its Vocational Scope.* — It will deal at the bottom with the technical or productive process; but it will also concern itself with the management of the farm; lay large stress upon such economic questions as access to the land, credit, co-operation; and it will emphasize a fuller community life, through the home, health, recreation, beauty, morals.

4. *It should be Comprehensive in its Activities.* — Teaching is the backbone of any system of education; but research and experimentation are vital to good teaching, particularly in such subjects as agriculture. And then it will extend itself not only to the pupils in the schools, but to every person on the land.

5. *It should be Liberal in its Spirit.* — It will emphasize the dignity of vocation. Vocation is a means of social service as well as an opportunity to make a living. It will impress upon the student mind the idea that vocation is also both a means of intellectual development and a great factor in the building of individual character. Vocational education will recognize that the public schools must assist in fitting boys and girls for citizenship in the largest sense, as well as in giving them capacity to meet the problems of their personal life.

6. *It should be Complete in its Correlation of Parts.* — This is to some degree a question of the division of labor between institutions. It is also a question of administrative responsi-

bility clearly defined. It means co-operative planning among all the different institutions.

7. *It should be an organic part of the State educational system.*

II. Types of Work to be Recognized.

1. *Formal Teaching.* — Organized teaching in the schools is obviously the main feature in a conventional discussion of education, and it must have a large share of this discussion; but in agricultural education there are one or two other considerations that must receive much attention. Agricultural education has set itself the task of reaching the masses of working farmers. Manifestly, more informal methods than those which require steady attendance at school must be used in this gigantic task. Moreover, formal agricultural teaching that keeps fresh and effective feeds on the results of thorough scientific investigation. Before proceeding to outline a plan for agricultural teaching we must note briefly these related aspects.

2. *Informal Teaching.* — One of the most fruitful phases in agricultural education is that of informal teaching. It is the sort of teaching which is represented by the present extension work. It is stimulating largely because of close contact of the specialist with the man in need of some definite aid. Its present methods are personal visits, public lectures, correspondence courses and extension schools. Beyond doubt the most effective reliance of informal teaching is the demonstration. If people can see with their own eyes the achievement of a certain scientific principle actually applied, they are ready to try for themselves. All this informal teaching must be made very concrete and definite. It needs systematization. It requires the best pedagogical methods that we can devise.

Educational Work of Administrative Boards: There is another type of informal agricultural education that needs to be co-ordinated with the rest. It is carried on by certain State boards in order that their administrative efficiency may be developed. Oftentimes in the enforcement of a law the crucial thing is not to invoke the law, but to make the persons involved see clearly what the law is for, and to understand the results that are expected from it. Nine-tenths of law enforcement, with respect to certain public relations, consists in education rather than in strict law enforcement. This function of the administrative boards ought to be perfectly understood by themselves as well as by the educational institutions; the two types of education should not conflict; they should be correlated in some definite fashion.

Educational Aspect of Voluntary Organizations: In discussing education we usually concern ourselves only with those agencies that are supported directly from the public treasury. But the many voluntary associations that exist serve their purposes largely because they are educational in their aims and methods. The grange is perhaps the best example. If we desire a well-rounded system of agricultural education we will endeavor to correlate the activities of both public and private agencies. The work of voluntary associations can often be organized and stimulated from the schools, though in no sense directed by the school. Study clubs in agriculture and in various phases of country life may gain in solidity and permanence of work if they can have assistance from some parts of the agricultural education system. Though informal and even unorganized, real education may result from the work of voluntary associations.

3. *Investigation and Experiment.* — These are important in all education; they are absolutely vital in a field of instruction where there are such large unexplored areas as is the case in agriculture. Agricultural science has had a rapid growth during the past quarter-century. Under the leadership of the United States Department of Agriculture and of agricultural experiment stations, a great body of knowledge has come into use concerning the soil, the cultivated plant, the domestic animal and their various relationships. But the wisest investigator knows that he has made but a beginning, and that we are still quite in ignorance of many of the most fundamental aspects of natural law as it applies to the practice of agriculture. Therefore we must go on with this study of nature's methods and laws, with better provision in men and money, and with better methods of applying the researches of the scientist to the practice of the working farmer.

Investigation cannot stop with the study of the physical and biological features of the farmer's problem. Great economic and social forces are at work, and are either upbuilding or breaking down the structure of rural civilization, industrial and social. These forces should be studied, also, by experts, who can withdraw themselves apart for a time and go deeply into underlying causes and essential remedies.

We should inventory our agricultural resources and chart conditions. It is not enough that we study abstract laws — we must know the actual situation that the working farmer has to face, with reference to soil, climate, market conditions, labor supply, and, indeed, all those economic and social as well as physical factors with which the working farmer must deal. We have hardly made more than a beginning in this field of investigation.

III. The Groups of Persons to be reached in a State System of Education.

A careful study of our problem would classify accurately the various groups of people who should be reached by an adequate system of agricultural education. I can offer here only a rough and tentative grouping: —

1. *Pupils in the "Grades" of the Public Schools.* — The material which enters into agriculture in its simpler forms is capital material for general educational use among pupils ranging in age from eight to fourteen. They may profit thereby not because they wish to become farmers, but because they may gain a part of their education by means of agricultural school gardens, home gardens, nature study, poultry clubs and corn clubs; those various types of work with plants and animals that are the beginning of agriculture should become an organic part of our school system, and available to all pupils under fourteen years of age. It is hardly necessary to remark that manual participation is essential if the pupil is to gain real education from this source. This work may also be considered helpful "prevocational" preparation for pupils who later study agriculture as a life work.

2. *High School Pupils desiring General Agriculture.* — The opportunity for education by means of agriculture should be carried through the high school, with elective courses, finding a place alongside the other subjects in the course. The teach-

ing should be very concrete and practical, and should bring the pupils into working touch, not alone with these processes by which plants and animals and all nature's forces are subordinated to human uses, but with the processes by which the business and life of rural people are related to the business and life of the nation as a whole.

3. *"Boy Farmers."* — We come now to those classes of pupils who are to be offered agricultural study rather definitely for the purpose of future vocational activities. The first group may theoretically comprise boys and girls under fourteen years of age. Personally, I question whether "vocational" agriculture should begin before fourteen. I have been impressed by the fact that Germany, as well as the other European countries which have patterned their educational systems after Germany, has declined to permit the serious study of vocational agriculture by boys and girls under fourteen years old. But in this country many States provide for vocational agriculture in the lower grades; we must recognize the possibility of a similar plan for Massachusetts.

4. *The Young Agriculturists.* — Numerically speaking, the most important group of pupils who should be provided with facilities for definite training in agriculture for vocational purposes are those between fourteen and seventeen or eighteen years of age. In an adequate system of agricultural education it is quite obvious that a vast majority of those persons who secure a schooling in agriculture will get that schooling in institutions that provide for them before they are eighteen or nineteen years of age. The facilities for this group will be twofold, first, agricultural departments of public high schools more or less highly differentiated, and second, a system of county, district or special schools. The "Junior Extension Service" of the agricultural college, which if fully developed will be an expansion of the present successful system of our boys' and girls' agricultural clubs, promises to be of great value also. Moreover, it has been proved that a course in agriculture or home economics given one hour a day for four years, in connection with other high school subjects, can be made to yield remarkably successful training for boys and girls preparing for agricultural practice and rural home life. But I predict that the

Massachusetts plan of agricultural departments, in which the pupil gives about half his time to agriculture, will become a very important and vital part of our State system of agricultural education — perhaps in some respects its characteristic feature — so far as pupils of high school age are concerned.

5. *Candidates for County Agricultural Schools.* — I believe in the county or district agricultural school, and that a complete system of agricultural education in any State must provide for a number of these schools. There are objections to them. They are rather expensive. If great care is not taken they may encroach upon the work of the agricultural college. It is sometimes said that if they are boarding schools they will take away the boys and girls from home at too tender an age, and if they are not boarding schools the area of their influence is limited. The county agricultural school in Essex County, while not a boarding school, reaches a very large constituency. I think, however, that it is a serious question whether a county school of agriculture ought to give a four-year course, except as an expedient during the early years of the development of a system of agricultural education. Its final place in the system of agricultural education is likely to be in advanced and specialized work for pupils of high school age who have had perhaps two years in the agricultural department of the high schools, or for those who have finished the work of such a department, but are not prepared for college. One advantage of the county agricultural school is that it may have a faculty of from six to twenty teachers, whereas in most cases the agricultural department of the public high school will have not over one teacher, or at most two or three teachers. These two types of schools should not in any way compete, but should complement one another.

6. *The College Student of Agriculture.* — There is next that group of pupils from eighteen years upward who will attend the agricultural college. Many of these will go back to farming; others will go into expert service in connection with agriculture. Sometimes the agricultural colleges are criticized because they do not send more of their graduates directly back to the farm. On theoretical grounds, and judging from the experience of agricultural colleges abroad as well as in this country, I should

say that we might consider ourselves fortunate if 40 per cent. of our graduates go back to the farm. There are perhaps another 40 per cent. who will go into agricultural vocations not connected with the farm, such as teaching, experimentation, county farm bureau work, agricultural journalism, and those business fields that have some connection with agriculture, such as farm machinery, the fertilizer business, etc. Probably there will always be a number of students graduating from an agricultural college who will never be directly connected with agriculture, for this is precisely what occurs in nearly all professional schools, including law and even medicine. But in the main the agricultural college is to be considered a professional school, or at least a semi-professional school, and it is here that there is an opportunity for the training for leadership in solving the larger problems of agriculture and country life.

7. *The Graduate Student.* — In connection with the agricultural college there is room for the development of a graduate school of agriculture. Not only room, but great need, for neither research nor teaching can be vitalized or pushed to its full measure of development unless constantly reinforced by men of the highest training.

8. *The Demand for Short Courses.* — In common with other agricultural colleges, our own has maintained for many years winter short courses, and, for a somewhat more restricted period, summer short courses in agriculture and country life. I am convinced that the time has arrived when these short courses must be developed more fully and fitted more completely into the State system of agricultural education. The men at the head of the agricultural departments of our public high schools, and especially those who are connected with the county agricultural schools, are thoroughly convinced that many of the pupils of these schools wish to attend an agricultural college for a period of from three months to an entire year, for the purpose of coming into contact with the recognized authorities in the various agricultural specialties that are emphasized in a well-regulated agricultural college. To such pupils this work would be a sort of graduate course. It would bring them into contact with the wider reaches of the subject, with the best prepared teachers, with the largest equipment,

and with the most complete resources for agricultural investigation and instruction. There are, moreover, a great many adults who would like special work in summer or winter who cannot take our regular courses. I am quite sure that we have not yet solved this problem; we have not yet given sufficient thought or attention to the working out of a system of short courses which will meet the needs of an increasing demand, and which at the same time is practical from the standpoint of college administration.

9. *The City Man and the Soil.* — In a State like Massachusetts, where the urban population constitutes nine-tenths of the people, there is rapidly coming on a demand for agricultural instruction to persons who are not immediately connected with agriculture, and perhaps who do not intend ever to be connected with agriculture as an industrial pursuit. The Homestead Commission has aroused interest in the problems of teaching agriculture to families, in the development of garden cities and in vacant-lot cultivation in the cities. It would appear that in this country, as in many of the more thickly populated countries of western Europe, there is need of a training which will give urban people a chance to work the soil, probably chiefly as an avocation, and yet to get something out of the soil which will help them in maintaining their families, and in rearing children to a healthy manhood and womanhood. There is also an increasing number of men and women, both among the wage earners and among the salaried men in the cities, who wish to become farmers, but who cannot take advantage of present institutions for agricultural education. We must assist these in some way.

10. *A Schooling for the Youth at Work on the Farm.* — In spite of all we can do through institutions, through formal schooling, there will always be a very large proportion of youths out of school who still need, and will take advantage of, some plan for continuing their agricultural education beyond school days. We need, then, extension schools in connection with our public school system, chiefly, perhaps, in connection with agricultural departments of public high schools and with the county agricultural schools, which shall during the evenings of the long winter give very definite instruction in agriculture, home eco-

nomics and country life to the boys and girls who cannot attend the regular day school. I am not sure whether we can ever adopt the plan used in some European countries, of requiring attendance at these schools; perhaps we may. At any rate, we can give the opportunity. Continuation or half-time courses in agriculture are also worth serious consideration.

11. *The Man in the Furrow.* — What has been said with reference to youths is even more true of adults. The extension service of the agricultural college has demonstrated the hunger for information that exists among the great masses of the people, and this work must be kept up, organized, systematized and better related to the other agencies. These adults will also be reached more or less by the administrative boards already referred to.

IV. The Scope of Agricultural Education.

I wish to lay added emphasis upon the fact that in developing a proper system of agricultural education we must get away from the old idea that agriculture is chiefly a matter of production. Primarily it is such. We must know the soil and other physical factors; we must know the plant and the animal; we must understand all physical and biological forces and their application to the task of producing food and clothing. But this is not all there is of agriculture, or even the chief part of agriculture; it is merely the foundation. We cannot expect individual success on the farm, nor a prosperous agricultural class, nor an adequate rural civilization unless other things than production are taken up and developed in our system of agricultural education. The distribution of agricultural products, the question of farm marketing, individual and co-operative, the question of buying supplies, the matter of credit, the investment of the surplus, protection against pests and foes, insurance — all are parts of a great problem of agricultural economics that should not be ignored, but should be worked in as a part of the system of agricultural education from the bottom to the top.

Our people who farm are still men and women. They live a common neighborhood life; they have their homes; they have their schools; they have their churches; they have their recreations; they must be in good health; they must have all of those things that go to make life worth living. Now these items should be subjects of education; they should be taught to youth from beginning to end of the school period — in their simpler forms to the young, and in a more complete way to the older pupils. In our agricultural education thus far we have placed the emphasis upon production, we have minimized distribution, we have ignored community life. We have given our attention to the foundations; we have neglected the superstructure. Unless we are very careful the superstructure will be one-sided and incomplete, and we will not have those results from large expenditures of money for agricultural education that a Commonwealth has a right to expect.

It is generally conceded that agricultural education should include home economics. The work as at present developed, however, is rather narrow in its scope and restricted in the area of its operations. The phrase "rural homemaking" hints at the real need and objective. This work should be developed as rapidly as possible, and should everywhere virtually parallel the work in agriculture.

One who has been fascinated by the wonderful results achieved in the Danish folk schools, or "people's high schools," cannot resist the temptation to suggest that in organizing a system of agricultural education consideration be given to the patriotic and even the vocational results of those studies that have nothing to do with agriculture itself. Danish educational statesmanship recognized the fact that intelligent and ardent lovers of a new Denmark, dependently rural, would be the bulwark of a real rural civilization. Studies of Denmark's history, literature, aspirations have produced a group of farmers who see the national implications of a successful and permanent agriculture, and a satisfying farm community life. There is a lesson for us in this experience of the best organized agricultural country in the world.

There is one thing more. Agriculture cannot be more efficient unless it is better organized. We have heard so much in recent months about organization in connection with some of the nations at war that perhaps we are shy of it. We are all rather individualistic, and slow about tying ourselves up with overhead organizations. It is true that we must not subordinate the individual; we must not subordinate the separate institution. We must allow for initiative and energy and all of those things that spring out of the glorious spirit of individualism. But the day has gone by when an individual or an institution can work by itself in a corner. It is so with agriculture. The task of organizing the farm, the farm home, the local rural communities, and the educational work of a State, the development of a national system of agriculture and country life, are tasks in rural organization. These things must be presented to the pupils in our agricultural educational system just as soon as they are capable of understanding. They must appreciate the spirit of co-operation; they must see the promise of organization; they must learn how to co-operate with other individuals and how to correlate other forces and institutions. This organization has to do not only with publicly supported institutions, but also with privately supported institutions like the grange. Let us give the broadest possible scope to our system of agricultural education.

V. A Suggestion concerning the Necessary Machinery for Agricultural Education.

Up to this point I have been endeavoring to formulate a few general principles. Let us pass to a brief outline of the system of institutions that seem to be needed in order to secure the full measure of agricultural education. This statement is made with hesitation, and its purpose is to make concrete the subject which we have been considering, and to offer a suggestion which may possibly form the basis for a definite program and policy: —

I. *The Public Schools.*

Presenting agricultural material as one means of education, through —

1. Boys' and girls' agricultural clubs: supervision by farm bureaus and the college.
2. School subjects: nature study; elementary agriculture (?).
3. Courses in agriculture in the high school: three to five hours per week for one to four years.

II. *The Public School.*

Teaching agriculture for vocational ends, through —

1. Agricultural departments of the high school: to reach pupils fourteen to sixteen years of age and sixteen to eighteen.

2. Continuation and extension schools: in connection with public high schools, to reach pupils no longer enrolled in the public schools, ages fourteen to eighteen.
3. Agricultural education for families, as proposed by the Homestead Commission.
4. The public schools as centers for extension work in agriculture and country life, carried on by the farm bureaus and the college.

III. *County or District Agricultural Schools.*

1. General and specialized agriculture: temporarily for boys fourteen to eighteen.
2. Specialized courses in agriculture, such as poultry husbandry, dairy husbandry, pomology, etc., as the eventual purpose for boys sixteen to eighteen; these courses correlate with the work of the agricultural departments of the high schools.
3. Extension work, in co-operation with the county farm bureaus and improvement leagues; this should be co-ordinated closely with the work of the county schools on the one hand, and with the agricultural college on the other.

IV. *The Agricultural College.*

1. Investigation.
    - (*a*) Research.
    - (*b*) Experimentation and testing.
    - (*c*) Co-operative studies in agricultural resources.
2. Teaching.
    - (*a*) The four-year course for a degree.
    - (*b*) Graduate work.
    - (*c*) Short courses for pupils of eighteen years and upwards.
        - A. Short courses of college grade, one to two years.
            - (1) For graduates of county agricultural schools.
            - (2) For graduates of agricultural departments of high schools.
            - (3) For graduates of high schools who have not had agriculture and are not eligible to the four-year course.
            - (4) For graduates of liberal arts colleges.
            - (5) For adults twenty-one years and over not eligible to four-year course.
        - B. Short courses giving elementary and specialized work, if the demand requires, for those eighteen years of age and upward.
            - (1) Winter course of twelve weeks for highly specialized work, such as butter making, etc.
            - (2) Winter course of twenty weeks for students desiring more general work.
            - (3) Summer course of six weeks, primarily for teachers of nonvocational agriculture.

3. Extension Service.
    (*a*) General extension work for adults.
        (1) Lectures and study clubs.
        (2) Extension schools.
        (3) Correspondence courses.
        (4) Demonstrations.
    (*b*) Junior extension work.
    (*c*) Extension work for urban and suburban residents.

Note. — It is understood that so far as possible work in rural home-making will parallel agricultural work throughout the whole system.

VI. Administration.

It is important to determine the proper administrative authority for the different lines of work, and how they may be correlated. I have no ready-made scheme to propose. The following suggestions may perhaps be helpful: —

1. Local school committees, or specially organized boards, should manage the agricultural work of the public schools, including the agricultural departments. Of course there will be special boards of control for county or district agricultural schools.

2. The State Board of Education represents the Commonwealth in guidance of its system of public education. I am not prepared to suggest a precise definition of the Board's functions in relation to the supervisory details of the agricultural phase of the system.

3. The various other State-supported boards, such as the Board of Agriculture, the Department of Health, etc., should be chiefly administrative bodies, and their educational work should be directed towards the carrying out of administrative functions.

4. The county farm bureaus, each in its own jurisdiction, will manage their distinctive enterprises. But their work is so intimately connected with that of all other agencies participating in a system of agricultural education that the closest correlation is essential.

5. The voluntary associations are under no legal obligation to co-operate with publicly supported agencies. In the interests of the rural people, however, they should endeavor to

correlate their work as far as possible with the public system of agricultural education.

6. The function of the agricultural college, aside from that of its recognized work of investigation, teaching, and extension service, should consist, in general, in being the main source of material and methods with respect to the teaching of agriculture of all grades. The leadership in this line should not be forced or perfunctory, but should lie in recognized efficiency and capacity to lead.

In this connection the preparation of teachers of agriculture becomes of vital concern. Undoubtedly normal schools can do a good deal, particularly with respect to teachers in the grades; but I think the work of the agricultural college in training teachers of agriculture for all grades should be more adequately developed.

VII. A Word of Recommendation.

I have discussed this subject because of the belief that the time is ripe for action with respect to establishing an adequate system of agricultural education for the Commonwealth. The college has direct relationship to the whole matter. I have explained that this discussion is in no measure complete, much less conclusive. It is meant to be suggestive only; it is hoped that it may be fruitful. The question is so important that I recommend that your Board request its committee on course of study and faculty to take such steps as in their judgment may be desirable to assist in the formulation of plans for a State system of agricultural education, and in better fitting the work of the college to the requirements of the system as a whole.

KENYON L. BUTTERFIELD,
President.

REPORTS OF OTHER ADMINISTRATIVE OFFICERS.

IN THE DEPARTMENTS OF INSTRUCTION.

The Dean.

In any year the work of the dean's office consists mainly of the supervision of absences and of scholarship. Probably three-fifths, if not two-thirds, of its time is devoted to this work. The remaining time is taken up with cases of minor discipline, conferences and correspondence. So it was during the past year.

The scholarship problems center in the first two years of the course. If the student gets a good start and does the work of these years fairly well he seldom gets into difficulty. The really crucial period for him in many respects, however, is the first semester of the first year; the transition from the ways and atmosphere of the preparatory school to those of college is not always easy. Recognizing this fact we introduced last year, at the suggestion of President Butterfield, a system of personal supervision of the boys who were making a bad beginning, and placed them in charge of Professor Machmer. He did his work so well, I am glad to say, that comparatively few freshmen failed at the end of the first semester. Much praise is due Professor Machmer for his splendid work and its happy outcome. We shall without question follow a similar plan next year.

I had hoped to be able to place before you at this time a statistical statement regarding some phases of scholarship and of absences, but Miss Christiansen's retirement has made it impossible this year. For compiling reports concerning minutiæ and details of the dean's office we need more help. The growth of the college and the consequent accumulation of data is felt as keenly in this office as in any other administrative office on the college grounds.

The fundamental and persistent problem of our office is, and always will be, I presume, the scholarship problem. Essentially, however, that is a faculty problem, and must in the last analysis be solved by the joint action of the teaching corps.

EDWARD M. LEWIS,
Dean.

The Director of the Graduate School.

From Sept. 1, 1914, to Sept. 1, 1915, the total number of students enrolled in the graduate school was 56; of these, 16 registered for the degree of doctor of philosophy, 27 for the degree of master of science, and 5 for the degree of master of agriculture. Eight registered as candidates for no degree. The number of students who have enrolled since the opening of the present college term is 52. At the last Commencement the degree of doctor of philosophy was conferred upon 5 candidates and the degree of master of science upon 5.

During the year the Board of Trustees voted to establish the following graduate courses: master of science in agronomy, master of agriculture in agronomy, master of science in animal husbandry, master of agriculture in animal husbandry.

The general plan of organization of the graduate school, which was adopted a year and a half ago by the trustees, is proving to be adequate and satisfactory in every respect. The number of graduate students attracted to this institution is very gratifying, and it is found that men come here from the very best educational institutions in the country.

Every two years there is held, under the direction of the Association of American Agricultural Colleges and Experiment Stations, a graduate summer school of agriculture. In 1916 this summer school is to be held at the Massachusetts Agricultural College. The director of the graduate school is serving as assistant dean of the summer school of agriculture, and is engaged in formulating plans for the school next summer.

CHARLES E. MARSHALL,
Director.

The Division of Agriculture.

The completion of Stockbridge Hall, offering as it does much needed facilities and equipment for the work of the different departments, marks this as a red letter year in the growth of the Division of Agriculture. The Departments of Agronomy, Animal Husbandry, Farm Administration, Poultry Husbandry and Rural Engineering have headquarters in the building, thus allowing the use of Flint Laboratory for the Dairy Department as originally planned.

During the year there have been two resignations in the Department of Animal Husbandry; first, Mr. George E. Story, the extension instructor, resigned to accept the position of head of the Department of Animal Husbandry at the University of Vermont. His going is a distinct loss to the institution as well as to the many friends he has made in his work throughout the State. His place has been filled by the appointment of Mr. W. F. Turner, who comes to us with five years' experience since his graduation from the Kansas Agricultural College, and who will begin work about December 1. The second resignation was that of the head of the department, Associate Professor J. A. McLean, who left us to take up extension work in the public service department of the Quaker Oats Company. His work will be largely in New England with headquarters in Boston, so that we look for his continued co-operation. His place at the college has been filled by the appointment of Prof. John C. McNutt, who will begin work Jan. 1, 1916.

An assistant professor of dairying and an instructor in farm administration have been added to the staff, as noted elsewhere.

The Department of Farm Administration has continued the farm management and survey work in co-operation with the Federal government and other State agencies.

On the farm, the drainage and improvement of the Nash property has continued as time and money would allow. The enforcement of the Saturday half holiday law will increase the labor expense of the farm at least 10 per cent., without a corresponding income to offset it.

Among the most pressing needs of the division are the remodeling of the farm dairy, an addition to the rural engineering laboratory, land for the research work in poultry husbandry and for a young stock pasture, and a small appropriation for an irrigation plant and modern farm tools. Most of these were mentioned in the last annual report. There is no question of the need — each month makes it more urgent.

One of the serious problems before us is how to satisfy the increasing demands of the college and extension work, and still allow the members of the staff sufficient time for study and research in order that they may keep abreast of the times in their respective subjects. This is an essential if the institution is to hold its place among others of the same class. The question of salaries is also very important. A bad break in the work occurs whenever a change in personnel is made, and often a financial increase is necessary in order to secure the same grade of service. Salaries should certainly be equal to those paid in other institutions, especially for heads of departments.

J. A. Foord,
Head of the Division.

The Division of Horticulture.

The Department of Market Gardening has been partially reorganized, Prof. H. F. Tompson coming to the nominal position of head of the department, but with his principal duties in the field in eastern Massachusetts. Prof. A. S. Thomson has become assistant professor in market gardening, doing the resident teaching. Prof. C. H. Thompson has been put in charge of courses in Horticulture 2, 3 and 4. This constitutes a substantial addition to our teaching staff. The resignation of Mr. P. H. Elwood, Jr., on September 1 takes from us a man who had proved very valuable in civic improvement extension work. His place has not yet been filled. No important changes have been made in courses, equipment or policies during the year.

There are many pressing needs in the Division of Horticulture, and it is hard to make a list of those which should be particularly emphasized. At the present moment the following seem to be most important: (1) The establishment of work in horticultural manufactures on a firm basis (this involves the erection of a suitable laboratory and the employment of a specialist in this field); (2) an adequate tract of forest land for the Department of Forestry; (3) further organization of the Department of Market Gardening, including the establishment of an out-station in eastern Massachusetts; (4) additional greenhouses; (5) an additional extension man in pomology.

At the present moment we are looking forward with much interest to the establishment of summer instruction in certain departments of the division. We believe that this will mark a radical change for the better. At the same time it will raise many practical questions, and will require the earnest effort of our instructors to adapt our instruction to the changed conditions.

We still believe that the problems involved in better methods of technical instruction are those to which we must give our immediate and earnest attention. The grounds service has grown so rapidly during the last three years that it now presents very serious problems, especially in the matter of adequate financial support. I have already presented a special report on this point.

F. A. Waugh,
Head of the Division.

The Division of Science.

In botany, during the absence of Dr. Stone, the department has been in charge of Professor Osmun. Some minor changes in methods of presentation of the courses have been made, with excellent results. Dr. P. J. Anderson has proved a distinct addition to the staff, and Mr. Doran has taken hold well. In chemistry the classification of the freshmen into two divisions — those who have and those who have not had chemistry before entrance — has worked well, but has produced difficulties in scheduling. The advisability of requiring chemistry for entrance is being considered. In entomology the year has been one of marked progress in the grade of work done by the students. Dr. Regan has proved a most excellent teacher and has greatly strengthened the department. In mathematics fairly satisfactory results have been attained, though eight sections of freshman have been made necessary by the large number in the class, and this has pressed the staff very hard. Microbiology is looking forward with much anticipation to its new laboratory and greater facilities, but has done its best under present conditions. In the Veterinary Department the work has gone about as usual, about fifty men now being given instruction. In zoölogy the work has been much as heretofore. Seven subjects are being taught.

Immediate and pressing needs in the division may be listed briefly as follows: —

In botany a careful revision and co-ordination of the courses. Proposals for this are now in the hands of the faculty committee on course of study. More students are taking botany, and with the enlarging of the scope of some of the courses, additional help will be needed; in chemistry a new building is the most pressing need; in entomology more shelf room in the library is much needed, as are some binocular microscopes. It is hoped that some of these new microscopes, which have practically quadrupled possibilities of work, can be obtained in the near future. A honey bottling equipment is greatly desired for beekeeping work. In mathematics the professor in charge believes that trigonometry should be transferred from the Department of Physics to that of mathematics where it logically belongs, in the interests of greatest efficiency. Large classes in plane surveying make the need for more transits and levels imperative. The most pressing need is for a major in the applied subjects of the department, so that these may be taken in a correlated way. At present the hour schedule is based on majors, and breaks into correlated work in mathematical subjects. The building used should be heated from the power plant. In veterinary science a thorough, well-taught course in animal physiology would greatly help all the science teachers. "Under our present arrangements conditions are far worse, as regards the subject of physiology, than they were formerly."

Some of the fundamental problems of the division may be mentioned: the problem of giving all students a sufficient understanding of chemistry to serve them well in their life vocations, and the securing and training of a few bright men for investigations in agricultural chemistry. In entomology the fundamental problem is, as always, to get the best work out of the students. I think there has been some gain in this during the past year.

The fundamental problem which applies to this entire college and to all others as well, as I see it, is, in this time when supply is rapidly approaching demand, to make students realize that it is the fittest which survive, and that ability being equal, a student who really gets the most from his course is the man who will win; also, how to insure that a technically trained man shall be generally cultured as well.

H. T. Fernald,
Chairman of the Division.

The Division of the Humanities.

The courses remain practically as they were last year. The English Department is becoming better regulated, and therefore stronger work is being done. The most pressing and most fundamental needs of the humanistic courses are permanence of location on the campus, with as much concentration of work in the same building as possible, and thorough equipment of classrooms for good instruction. The instructors in this division are the nomads of the campus, drifting from building to building and adapting themselves as well as possible to the temporary conditions over which they have little control. Such wanderings are not conducive to the best instruction, and make the best methods of class work well-nigh impossible. When the instructor does not have a recognized status in the building where his classes are held he neither feels like proposing changes to suit his needs nor would he in all cases be permitted to carry them out. I believe that as soon as these needs shall be met for the division there will develop a better quality of work and a stronger atmosphere of scholarship.

R. J. Sprague,
Head of the Division.

The Division of Rural Social Science.

The work of the Department of Agricultural Economics has been carried on along three lines during the past year — the regular classroom instruction, extension work and the investigations. The extension work of the last year has been most gratifying; it has included the organization and supervision of co-operative associations, seventeen of these societies having been organized within the State during the last two years. The marketing of farm produce has also received much attention. Two special investigations have been conducted, one of these a very complete study of the marketing of milk in Massachusetts, the other a study of the methods and costs of the distribution of onions, with especial reference to the crop of the Connecticut valley. Reports of both of these investigations are nearly ready for publication.

The work in the Department of Agricultural Education has continued along the lines already started. The head of the department states the following as representing the most pressing immediate needs of the department: (1) office facilities, (*a*) for the clerical work connected with the boys' and girls' clubs; (*b*) for private consultation with students; (2) teaching opportunities for those intending to teach; (3) enlargement of scope of the work by the introduction of a two-year training course for rural teachers; (4) building for carrying on experimental teaching and teacher-training; (5) additional help, (*a*) one person to take charge of the four-year college student in training for teaching; (*b*) one person in charge of the two-year training course for rural schools; (*c*) one person to take charge of the office management of the boys' and girls' clubs.

During the past college year the Department of Rural Sociology was virtually without a leader, owing to the resignation of Professor Eyerly, which took effect in August, 1914. The fact that the department had no administrative head was a real handicap in the development of the work as well as in the attraction of students to the department. This fall, however, Prof. John Phelan assumed the headship of this department, and is conducting the work in a most satisfactory manner. The courses of study are now being revised, and outlines are being prepared for graduate work in the department.

Kenyon L. Butterfield,
Head of the Division.

General Departments reporting to the President.

Military Department.

War department orders state that instruction in all educational institutions, at which an officer of the army is detailed, must include instruction in the infantry drill regulations, field service regulations, and small arms firing regulations; it may be said that cadets will be taught to drill, to scout and to shoot. With the beginning of the present scholastic year a more systematic system of imparting these three fundamentals has been inaugurated by which the student in his freshman year is placed in companies that are given close and extended order drill; the sophomores in companies that receive training in field problems; the juniors in companies that, under careful coaching, are taught to shoot and to control and direct the firing at field targets. The training for all is made as intensive as possible. It has been very noticeable that these changes have done much to hold the interest of the students, which is very important. During the winter months the theoretical instruction will go on varied by lectures by prominent officers of the regular army and the Massachusetts militia. It is considered very important that the students should have sound and correct ideas of the aims, purpose and necessity of the army, and the necessity for proper military organization, including not only the troops with the colors, but necessary reserves.

At the present time the outdoor work is handicapped by a drill hall that was built about thirty years ago when the college had an enrollment of about 150. On one rainy Wednesday this fall I had the regiment form inside the hall, but the room was so crowded and poorly ventilated that it was necessary to dismiss four of the eight companies. The armory and storage rooms are as inadequate as the hall. The drill hall is doing duty as a gymnasium, also, and much as we need a new hall, I feel that the student body would be more benefited by a new and modern gymnasium than any building that could be erected on the campus.

Not until this year has target practice been made a part of the regular outdoor instruction. The range is a little over two miles from college. There are five double targets. About one and one-half hours are spent in going and coming from the range. This leaves about one and one-half hours to shoot. Barely five shots per man can be fired each week. With five more targets this important instruction could be more than doubled. A handicap to efficient work is the arrangement of the course of study in the Military Department, which requires theoretical instruction for only the freshman and sophomore classes, and not the juniors and seniors. The result is that there is no opportunity to teach the cadet first sergeants and lieutenants (juniors) and the cadet captains and higher officers (seniors) their duties, except on the drill ground. The proper carrying out of orders rests on these men. A company of 150 men in an attack must be drilled in signals almost as thoroughly as a football team, and with the few hours we have a week for drill the place for this instruction is the classroom. One of the remarks of Captain Schindel on the inspection of a field exercise last spring was, "There was almost a total lack of team work."

It would seem that the real aim of the military work should be to fit the graduate for his duties of citizenship for the military service in case he should be needed. Heretofore there has been no practical way to utilize this knowledge; a future war was a vague and far-away idea that did not appeal to the undergraduate, and the main object of the Military Department being kept on the same efficient basis as other departments of a college was that any inefficiency was prejudicial to all. The proposed colonial army, many details of which are still unpublished, is evidently based on the results of college camps. War Department orders state that "the main object of military instruction given at civil institutions is to qualify students to be company officers of infantry volunteers or militia." There will be a great dearth of officers for the 133,000 men it is proposed to raise next summer. I believe that I will be able to get for the twelve cadet officers of the senior class an appointment, after examination, as second lieutenant in this proposed colonial army, should they desire it, which office would pay $155 per month while with the colors. It may be that many of the underclassmen may enlist with the idea that from their experience they will be made noncommissioned officers, which offices would pay from $30 to $60 a month. Should this legislation pass, it would be a great stimulant to the military work in all colleges and tend to standardize the work.

H. W. Fleet,
Professor of Military Science and Tactics.

Department of Physical Education and Hygiene.

The work of the department has been conducted through the year along the following lines: —

1. Each student in the entering class was given a physical examination during the first month of the college year, thus reducing the possibility of any injury arising from ignorance. In the examination especial care was taken to detect any defects of the vital organs, sight and hearing. Each person is given a short talk following his examination concerning his condition, the kind of exercise he should have, and the proper care of his body.

2. The freshman class was given a course of lectures and written quizzes on personal hygiene during the first semester.

3. For the past few years the department has been giving first aid in cases of minor injuries or illness, advising the calling of a physician when necessary, and seeing that all ill or injured students are properly cared for. Beginning with the opening of the college in September we have had the use of the new infirmary. This has increased the efficiency of our work and in every way raised the standard of service to the student. In all this work the department has been in constant touch with the Department of Microbiology through the health committee of the college.

4. During the winter months the department requires three hours of physical exercise per week for each member of the

three lower classes. Those men who have been found by physical examination to be physically normal are permitted to elect one of the several athletic activities; those who have been found to be below normal physically are given individual instruction in so far as our present equipment will permit. Walking trips may be substituted for physical exercise in the gymnasium, and during the past year from 150 to 200 students have elected this form of exercise. The work of the indoor classes of from 30 to 40 men each consists of gymnastic exercises, such games as basketball and indoor baseball.

The physical director is general manager of athletics, supervising arrangements for contests with other colleges, buying supplies for the teams, assisting in the coaching, and having final control over players and games.

The interest in intercollegiate and intramural activities has been steadily growing. An accurate estimate of the participation in all sports during the year shows that in track about 75 men participated; cross country, 50; hockey, 75; baseball, 175; tennis, 25; football, 140; and basketball (other than required gymnasium), 40. After counting out duplications we find that approximately 50 per cent. of the student body voluntarily took part in some form of supervised athletic sport during the year.

The new athletic field is so far toward completion that it was possible to use it for college games last fall. With the opening of the spring this whole field of nearly 8 acres will be thrown open to general use, and should offer a greater inducement than anything we have had before for universal participation in outdoor sports.

The limited quarters in which the regular gymnasium work is to be carried on in the winter season make it impossible to do indoor gymnastics which can compare in anywise favorably with those of other colleges. From December 1 to April 1 the drill hall floor is in almost constant use from 8 o'clock in the morning until 9 o'clock at night.

The immediate pressing need of this department is a suitable gymnasium for the physical training of students during the winter months. Every student should receive gymnastic instruction and training of such a nature as to keep his physical education and development on a par with his mental development. Many of our students who should receive individual attention and treatment are neglected simply because the present building is too small, unsanitary and poorly equipped. A suitable gymnasium with a swimming pool is our greatest need.

The greatest problem of this department is to provide means for our students to follow out the exercises prescribed for them, and require those who are not themselves inclined to take exercise to take some form of systematic exercise at least three times a week. With the completion of the athletic field our ideal of having every student taking part in some form of active exercise may be realized for at least half the year, but during the winter months, when there is no military drill and regular exercise is a necessity, we are confronted with the problem of finding forms of exercise which are possible with our present equipment.

CURRY S. HICKS,
Physical Director.

THE LIBRARY.

In spite of our very crowded conditions and the increasing number of teachers and students making use of the library, the past year has been one of marked interest. The adoption of the fundamental library policy of making the main catalogue in the college library a complete inventory of all the book resources of the institution will always count for the best library interests. The establishment of the agricultural reference library in Stockbridge Hall will mean a great deal toward strengthening all agricultural activities, and also make the new building better equipped to meet the demands which will be made upon it.

The work of recataloguing the library has continued without serious interruption. The new card catalogue contains 69,956 cards for 24,674 old books recatalogued, and 14,141 new books added since April 1, 1910.

Including several sets of scientific periodicals which have been made complete or added to the library during the past year there have been added 4,005 volumes regularly accessioned and catalogued. This shows a total of 48,411 volumes, 20 per-cent. having been added to the college library during the past seven years, and indicating somewhat the recent growth of the department.

Library extension work means more to us than ever before; 572 books and 106 bulletins have been loaned out to 33 borrowing libraries throughout the State, and a large number of letters have been written to library officials and others in regard to the purchase of book material. Five library leaflets on farm and garden papers, books for young gardeners, farm women and fruit growers, and country-life books for teachers have been published and distributed in various ways. The school for library workers which was held here as part of the summer school proved more successful than was anticipated. Seventeen full-time and 8 part-time registrations indicate somewhat the interest in the first school of this kind held in connection with any agricultural college. We hope to continue and enlarge upon this line of activity.

Of greater importance, however, than anything referred to above is the need for a new library building. I understand that the president will deal with this matter at some length in his report, and I will only say that just as long as we continue in our present crowded and otherwise undesirable quarters just so long shall we fail in our best service to the teachers and students who come to us for assistance.

CHARLES R. GREEN,
Librarian.

The Supervisor of Short Courses.

The short courses given at this college have continued to draw not only a large number of interested people, but also many students who have had the advantage of attendance at some of the finest colleges and universities of this and other countries. The cosmopolitan nature of the groups making up the short courses is such that more than ordinary credit should be given members of the teaching staff for their successful efforts to adapt their courses to the understanding of some who have had practically no educational advantages, to others with the finest of collegiate training, and to business men with keen powers of discernment and years of experience, making their teachings acceptable and satisfactory to all.

Due to the prevalence of the foot and mouth disease it was deemed wise to cancel all short courses between March 1 and the end of the college year, so that farmers' week, the school for town officers (arranged for the first time), tree wardens' school, Polish farmers' day, conferences of feed dealers, seed dealers, fertilizer agents (which were contemplated), and the beekeepers' course and convention were not held. This accounts for the falling off in statistics given later for this year.

A. Winter Schools.

In the ten weeks' winter school of 1915, 24 courses were offered in agriculture, horticulture, the allied sciences and in rural social science.

The school for apple packing, held in November, 1915, was attended by 19 men and women. No doubt larger numbers will desire to take advantage of this another year, after the State apple packing law goes into effect.

It is to be hoped that the plan of inviting feed dealers, seed dealers, fertilizer agents, milk inspectors and other persons interested in the various phases of agriculture may be consummated, and that by so doing, station, college and commercial interests may meet for a free and frank discussion of problems of mutual interest, and that a better working understanding will result from such gatherings.

The registration in the winter school is so large that additional assistants should be placed in several departments having the largest registration during the short course work, but funds available at present do not permit of this.

B. Summer Schools.

Forty courses were offered during the summer school of agriculture and country life.

The regular summer school in spirit and application was probably the best that we have ever held.

For some unknown reason the attendance at the school for rural social service was not as large as usual. Every effort during the past two years has been made to strengthen these courses and to provide work which would appeal to those interested in the broader phases of rural life.

The school for library workers, held for the first time, was a success. Twenty-five people attended and were evidently greatly helped by the work given. This was probably the first school of its kind to be held in connection with an agricultural college, and should be continued next year.

The agricultural camps, four in number, continued to be popular, and we believe that these have a lasting effect in impressing the boys and girls in these camps with a true conception of the magnitude and importance of the agricultural industry. The third boys' camp was made up of those who won third prize in the various State-wide club contests. A girls' camp, under the direction of Miss Nash, made up of the third prize winners in the home economics clubs, was held at the college for the first time this year. We ought to secure before another summer, if possible, enough 8 by 10 khaki tents to shelter those who attend these camps. The expenditure would probably be about $200. The large fair exhibit tent is not storm proof, neither does it give the best possible conditions for camp discipline.

The poultry convention continues to enlist the interest of a large number of poultry men. More than 600 attended this year.

The conference on community planning was even more successful than usual. I am told that more than ever before this took on the nature of a real conference. Several of the official as well as voluntary organizations assisted in the furnishing of speakers, bringing the conference to the attention of a large number of people, and in other ways helping to make it a success.

Plans are under way to correlate all of our summer school activities during the summer school of 1916 with those of the graduate school of agriculture, which is to be held at the college.

Recommendations.

With additional funds to carry on the work and to give needed assistants to departments which are now already overworked, there would be many things which might be recommended, but which at the present time are entirely out of the question. Some of these are: —

1. The short courses of the institution arouse the interest of a large number of mature men and women throughout the State, and may serve a very useful purpose in helping them properly to organize their farming and to teach them the latest and best practices. These people also become loyal supporters of the college. The short courses ought to be enlarged, so that all those who desire to come may secure satisfactory work.

2. Special arrangements should be made for the admission of students in the senior year, or those who have finished courses at the county schools of agriculture. Unless this is done these schools will be compelled to spend large sums of money in duplicating equipment already in existence at the college.

3. The time has come when progressive short courses, covering two and even three winters, should be offered. This can be done when equipment and instructors can be provided.

4. When the four-term-a-year plan is adopted new plans for the winter and summer schools should be made so that the regular work and short course work may be correlated and duplications avoided.

5. The funds available for all of the short course activities are inadequate. Now that the short courses are considered as regular college instruction it would seem that the cost of maintaining the short courses should be cared for out of regular college funds. A few thousand dollars added to the present apportionment would place these on a sound basis. The money now apportioned from extension funds for short courses could be used to relieve the pressure for more extension work in some departments.

I wish to repeat the recommendation made in the report of last year, that a faculty committee on appointments, to take care of applications coming in for short courses as well as regular college men, be appointed.

W. D. Hurd,
Supervisor of Short Courses.

THE DIRECTOR OF THE EXPERIMENT STATION.

I. Review of the Year.

There have been comparatively few changes in major positions on the station staff during the year. Dr. Stone's leave of absence was continued until October 1, since which date he has resumed work, devoting himself particularly to the preparation for publication of the results of some of his lines of investigation. In the Veterinary Department Miss Beryl Paige began work on the test for bacillary white diarrhœa in January, while Mr. A. P. Sturtevant entered the department on the first of July to undertake a line of research, of Adams fund grade, on bee diseases.

The lines of work followed in the different departments of the experiment station have in general been the same as those which have engaged their attention during recent years, but during the year investigations have been started in two departments of the college not previously engaged in station work, viz., agricultural economics and microbiology. In the cranberry substation arrangements have been made with the Bureau of Plant Industry of the United States Department of Agriculture for co-operative experiments in the cultivation of the blueberry, and preparatory work has already begun. In the asparagus substation seeds and roots of improved rust-resistant strains of asparagus have been distributed among a large number of growers. This distribution has included 68 lots of roots and 217 packets of seeds. In the Department of Horticulture somewhat less work is being done in plant breeding, as the research work in pomology has made greater demands upon the time of members of the staff. In the Veterinary Department an entirely new line of investigation has been undertaken, viz., the study of the nature and methods of transmission of American foul brood.

Results obtained.

The heads of all departments report uninterrupted and, in general, satisfactory progress of the investigations under way. A few only of the more significant results obtained will be briefly stated.

Department of Agriculture. — 1. In the experiment for comparison of different phosphates it has been noted that the dissolved phosphates greatly stimulate the early growth of the grass — an effect likely to be of great importance on account of the fact that the moisture and other climatic conditions are usually much more favorable to the growth of grass in early spring than later.

2. In the series of experiments comparing different sources of potash difficulty was experienced in obtaining one of the materials which has been under trial. Accordingly, it was thought best to withhold the potash from all. It was noted that the yield on all plots which have been receiving potash annually for a long series of years fell off in very marked degree, in this first season without potash indicating apparently less residual effect than has generally been believed to exist.

3. In the comparison of muriate and sulfate of potash with small fruits the latter, as in recent years, gave a crop about 50 per cent. greater than the former.

4. In the field where different materials furnishing nitrogen are under comparison, both with and without lime, one of the most striking results was the substantial equality of the yields on the limed portion of plots which have received no nitrogen for thirty-one years with the yields obtained on the plots to which nitrogen has been annually applied. Another striking result was the high yield obtained on the unlimed portions of the nitrate of soda plots, indicating the beneficial effect of the residual soda in preventing soil acidity.

5. In the experiments testing the residual effect of application of manure, respectively, in the winter and in spring, a striking result was a more vigorous growth in the early spring on the plots to which the manure in earlier years was applied in spring, and the earlier ripening of the crop — soy beans.

6. Many fields of tobacco in this section failed to produce a satisfactory crop during the past season. A co-operative test with fertilizers on a small scale indicated that the apparent cause of the unsatisfactory growth was shortage of plant food in available form, particularly of nitrogen — a shortage due, no doubt, to the excessive rainfall, for fertilizers in accordance with the usual practice had been used.

Cranberry Substation. — 1. There has been discoverd an egg parasite of the fruit worm, which seems to be remarkably effective in reducing the amount of damage from that worm.

2. Knowledge of various injurious insects, their life history and habits has been extended in many directions, with the result that methods of preventing injury are better understood.

3. A preliminary trial indicates that a covering of such shade cloth as is used by tobacco growers may be a useful means of preventing frost damage.

4. Rather serious injury to the roots of the vines has been observed to follow spraying according to methods which have been recommended for preventing fungous diseases.

Asparagus Substation. — The fertilizer experiments indicate —

1. That among growers a larger amount of fertilizer than can be useful to the crop is frequently employed.

2. That nitrate of soda applied, at least in part, at the close of the cutting season gives better results than with all applied in the spring.

3. That phosphoric acid appears to be relatively unimportant, while nitrogen and potash in available forms largely increase the crop, the muriate being the best form of the latter.

Department of Horticulture. — 1. A large amount of data on plant breeding has been accumulated which, in the opinion of Professor Waugh, will serve as a basis for valuable conclusions, if the work can be continued. It has been shown that commercial seed of squashes is very seriously mixed.

2. The work upon the mutual influence of stock and scion has made fairly satisfactory progress. Enough trees have been rooted to set about three-quarters of the 10-acre orchard.

3. A large number of varieties of all our principal fruits are under comparison, and valuable data in regard to these have been obtained.

Department of Chemistry. — 1. The perfection of a new method for determining stearic acid in fats, the use of which shows that butter fat contains from 8 to 22 per cent. of this acid instead of about 2 per cent., as formerly supposed.

2. The perfection of a new method for determining the unsaponifiable matter in fat.

3. Determination of the digestibility of cabbages, carrots, pumpkins, garbage tankage and vegetable ivory meal.

4. Sulfate of ammonia used as a fertilizer removes lime and forms sulfates of iron, alumnina and manganese, which seem to act in dilute solutions as plant poisons.

5. The plant-food value of different forms of organic nitrogen in commercial fertilizers has been studied, and experiments show that it varies widely.

Department of Vegetable Physiology and Pathology. — 1. The mosaic disease investigation has been nearly completed, and Mr. Chapman will be ready to report in the near future.

2. The discovery of white pine blister rust in the four western counties has indicated the necessity for investigation of certain phases of the life history of the causal fungus with a view to working out some means of control, as the disease is a very serious one and is already quite widespread in the western part of the State.

3. On account of the abnormally wet summer numerous serious diseases were unusually abundant, and an unusual number of samples of diseased plant tissues have been examined and advice given.

Department of Entomology. — Dr. Fernald reports that one or two of the leading lines of investigation in the Department of Entomology will probably be completed with one more season's work. Satisfactory progress has been made during the past season.

Poultry Department. — 1. A study of the effect of broodiness on egg production shows that it seriously reduces returns. Dr. Goodale estimates the reduction in value of eggs produced amounts to from $0.80 to $1 per hen. Some progress has been made in the effort to produce nonbroody strains of the Rhode Island Red, a breed which is ordinarily broody.

2. Much progress has been made in working out a satisfactory method of raising chicks artificially. Dr. Goodale reports that faster growth and larger chicks were secured than ever before, and that the results were all that could be hoped for.

Veterinary Department. — 1. The principal emphasis has been laid upon methods of diagnosing fowls which harbor white diarrhœa. The agglutination test has been brought to a higher degree of perfection.

2. An effort to eradicate white diarrhœa from the flocks of the State, through work in co-operation with the Extension Service, has been begun.

Department of Microbiology. — Dr. Marshall reports that the investigational work naturally falls into two divisions — dairy microbiology and soil microbiology. The department is also engaged in investigations under the De Laval graduate assistant fund. The department has also devoted considerable time to microbial analytical work in milk, preparation of legume cultures and dairy cultures, and the determination of organisms in human diseases (the latter for the town of Amherst). The work in soil microbiology will be somewhat impeded, through lack of suitable laboratory accommodations, until the completion of the new building. In other directions the work of the department has made satisfactory progress.

The Department of Agricultural Economics. — Investigations in this department connected with the work of the experiment station have been directed along two principal lines: —

1. Methods of onion storage and distribution.
2. Investigation of the cost of producing milk on typical Massachusetts farms.

Satisfactory progress in both lines of investigation has been made, and Dr. Cance reports that the onion investigation is being rounded into final form.

II. Immediate Pressing Needs.

The different heads of departments, in response to my invitation that they indicate any immediate pressing needs in their several departments, have called attention to a considerable number of things which are highly desirable, indeed necessary, to a thoroughly satisfactory prosecution of our work. Without expressing my own opinion as to the relative necessity for the different things named by department heads, I will quote briefly from each: —

Professor Waugh: Two important needs should be emphasized — first, the work in plant breeding now being laid off by Dr. Shaw should be taken up by a well-trained plant breeder and carried to practical conclusions; second, experiment work in market gardening should be speedily established.

Dr. Lindsey: The department has no pressing needs. It does, however, need improved facilities for conducting feeding experiments, and is likely to need more laboratory facilities and assistants if the work continues to increase. He needs an assistant in animal nutrition.

Professor Osmun: The unexpected discovery of the white pine blister rust over a large territory presses home more strongly the need of some sort of plant disease survey work. Reorganization of the department staff, assigning to each member specific duties and field of investigation is needed.

Dr. Fernald emphasizes strongly the need for experiments in spraying a plantation of about twenty different kinds of trees, including fruit, small fruit, shade trees and forest trees, to be the property of the department and to be used for experimental purposes by this department only. He also calls attention to the need of an addition to the entomological staff for experimental work.

Professor Graham calls attention to the necessity for more land.

Dr. Paige states that the most pressing need is for additional help to carry on the white diarrhœa work.

Almost every department calls attention to the fact that more money is either necessary or can at any rate be used to great advantage. In the Agricultural Department we shall need a new vegetation house in the near future, and the work in connection with the Tillson Farm will necessitate some addition to our outdoor workers.

An analysis of the situation indicates to my mind that we must in the near future plan to enlarge our staff. In the Agricultural Department we need to do more work in connection with tobacco and onions, and we may need a tobacco specialist. Another man can be used to great advantage in entomology. We certainly need more assistance to carry on the white diarrhœa work. If the market gardeners secure an appropriation we shall need one or more men for investigation in that line of work; and if the seed law passes, we must have a seed specialist.

The recent discovery that white pine blister rust, the most serious disease affecting any of our forest trees, has gained an extensive foothold in the four western counties indicates the desirability of intensive work in the Department of Plant Physiology and Pathology on this disease. This can perhaps for the present be managed without additional assistance, but developments may be such that we shall greatly need to employ the services of a pathologist.

While the acquisition of the Tillson Farm will for the time being meet some of the more pressing needs for more land, it will not satisfy our requirements for any great length of time. Indeed, the Poultry Department now greatly needs land for extension on the experimental side, and the acquisition of land lying nearer the poultry center than the Tillson Farm is greatly to be desired in the very near future.

W. P. Brooks,
Director.

THE DIRECTOR OF THE EXTENSION SERVICE.

General Administration.

The work of the Extension Service has proceeded along much the same lines during the past year as in 1914. Little attempt has been made to organize new lines of work, the greater effort being put on the better organization of lines already under way, the systematizing of records, reports, etc., and the attempt to better correlate the extension work of the college with the teaching and research sections.

It has been gratifying to know that the type of organization which has been worked out at this college has fully met the requirements laid down by committees representing the Federal and State agencies, and has been used as a model by several States which have lately taken up the definite organization of extension work.

The first year's work under the Smith-Lever appropriation has been carried on satisfactorily to those in Washington who have supervision of the work. The accounts have been audited, and all expenditures without exception have been approved. These funds are being used at present for full or partial support of projects dealing with fruit growing, animal husbandry, boys' and girls' club work, poultry husbandry, farm management demonstrations, home economics, dairying, extension schools, county and district agricultural agents and printing. The additional amount available from these funds during the year July 1, 1915, to June 30, 1916, is $2,930.75.

During the past year all the extension work of the institution has been placed on a definite written project basis. Each project has had the approval of heads of departments, directors, the president of the college, and the Washington authorities. The co-operative relationships with the United States Department of Agriculture established in 1914 have been maintained to our own and, I believe, the general satisfaction of the States Relations Service at Washington.

Besides the co-operative work in agriculture and home economics under the Smith-Lever act, the United States Department of Agriculture is helping us to maintain, with their appropriation for demonstrations outside the cotton belt, the following lines: boys' and girls' clubs, farm management demonstrations, and assistant State leader and farm bureau work. Every effort has been made to maintain cordial co-operative relationships with all other official and voluntary organizations within the Commonwealth in work of mutual interest. During the year arrangements have been made for furnishing clerical help to several departments, and members of the teaching faculty in agricultural education, pomology, agricultural economics, landscape gardening, farm management and beekeeping are now being paid from extension funds for the proportion of their time which is given to extension work.

During the month of August, in answer to urgent calls from the superintendents of various State institutions for help on their agricultural problems, eight members of the faculty visited seventeen of these institutions on a tour of inspection and advice. The work of each was gone over, plans were discussed, and a written report approved by all members of the party has been submitted to each. This is the initial step in what promises to be helpful co-operative work between the college and the other institutions supported by State funds.

In January, 1915, a biennial report of the Extension Service covering 40 pages was published.

During the past year the Extension Service has suffered from the loss of several of the most efficient members of the staff. Those who have left us have all accepted positions of trust and responsibility, and it is gratifying to know that we have had as members of our staff persons who are sought by other States and colleges to become heads of some of their most important departments.

Work carried on by State Funds alone.

Correspondence Courses and Publicity. — The work in the correspondence courses has been carried on along lines similar to the past year. The courses in floriculture, pedagogy of agriculture, gardening and elementary agriculture have been dropped. Courses in human nutrition, apple growing and small-fruit culture have been added. Some other courses, due to inability of the faculty to carry them, have been temporarily discontinued.

The supervisor of these courses recommends that members of the faculty be paid for preparing lessons and correcting the questions as they are returned. Graduate students or capable seniors might be engaged for this latter work. Before the correspondence courses can be developed as they should be it will be necessary to provide more funds to be used in preparing the courses, correcting papers, in the employment of additional clerical help, and for supplies and maintenance. The group study idea is being adopted in several places, and promises to be very successful. It is hoped that some co-operative arrangements can be made with the Correspondence Course Department of the State Board of Education created by the last Legislature, in order that our work may be enlarged and organized on a more satisfactory basis.

Civic Improvement. — The work in civic improvement during the past year has been largely in service rendered to small towns, school boards and individuals. There is a distinct and growing demand for this work. Work has been carried on in connection with 33 projects in 25 towns. Fifty-two plans have been prepared. Ten reports have been rendered. Six separate pieces of work have been supervised. Twenty-nine consultations have been held and 32 lectures have been given.

The civic improvement work has been made a part of the work in extension schools, exhibits and demonstrations. The problems to be taken up during the coming year are related to school ground improvement and playgrounds (urgently needed in small towns and rural communities). The obtaining of public reservations for recreational purposes is also important.

The preparation of farmhouse plans has aroused interest, and should be followed up by further and more extensive studies of plans for other buildings and for the laying out of the farmstead. Surveys should be made to furnish a basis for rural planning work.

The position of extension instructor in civic improvement has not as yet been filled, which handicaps the development of the work.

M. A. C. Agricultural Improvement Association. — No constructive work was carried out by this association during the year. The canceling of farmers' week at the college did not give opportunity for the regular annual meeting at that time. The demand for choice strains of corn and potatoes was so great that members had no difficulty in disposing of the supply on hand. The season of 1914 was decidedly unfavorable for the production of choice seed, which accounted for the small supply. An effort will be made to revive interest in this association, to the end that it may serve the interests of the State in the manner originally intended.

Community Planning. — During the past year the work of community planning has emerged from the experimental stage as to methods of procedure, and has settled down to the adoption of well-planned long-term policies in several communities. Extension schools of community planning were held in Littleton, Bolton, Framingham and Hubbardston. County conferences were held in Essex, Barnstable and Hampshire counties. Work in community planning has been made a part of the co-operative work carried on with the State Board of Education through the vocational instructors during this year. The instructors in New Salem, Leominster, Reading, Brimfield, Clinton, Sutton, Ashfield, Harwich, Petersham and Hadley have taken up this work.

Assistance in community organization, studying the needs of counties, etc., has been rendered to county agents in Hampshire, Franklin, Plymouth, Norfolk, Barnstable and Worcester counties. Follow-up work (in communities already entering into long-term policy planning) has been carried on in Bolton, Hubbardston, Tyringham, Wilbraham, Brimfield, Montague, Sterling, Charlton, Billerica, Shutesbury, Lanesborough, Chartley, Berlin and Littleton. New communities taking up the work for the first time are South Athol, North Dana, North Leominster, Chester, Sutton, Harwich, Westminster, Petersham and Framingham. Mr. Morgan has continued to act as secretary of the Massachusetts Federation for Rural Progress during the year, and was selected as a special agent of the Massachusetts Development Committee.

If Mr. Morgan is to continue as secretary of the Federation, and if a considerable amount of work is brought into this office as a result of his connection with the Massachusetts Development Committee, more clerical help must be provided. Office facilities are now unsatisfactory, but this may be remedied when Room G becomes available. If this work is to be conducted with the thoroughness which it demands, and if follow-up work is to be practiced in the way that it should be, either another man must be provided or else the work as now laid out must be curtailed.

Library Extension Work. — During the year the practice of loaning traveling libraries to small towns has been developed more than in past years. Five hundred and seventy-two books and 106 bulletins have been loaned to 33 libraries. A large number of letters have been written to library officers in regard to the purchase and use of books on agriculture and related topics. Five library leaflets on agricultural books have been published and distributed. This phase of our extension work is well defined, and the librarian should receive more financial and clerical assistance in order that the work may be enlarged and extended.

Lectures and Lecture Courses. — The supervision of this work was transferred from Mr. Forbush to Professor Waid, March 1, 1915. An attempt has been made to systematize the lecture work of the institution, keeping more careful records of the lectures given by members of the regular faculty doing extension work. Monthly reports are now secured and a card index by towns is being arranged.

Many lectures and lecture courses are now arranged through county agents, and it is hoped that proper co-operative relationships with the farm bureaus will exist so that the largest possible amount of good may be rendered in different sections of the State. An attempt is being made to give fewer single lectures and to have courses or series arranged wherever possible. The giving of a course of 45 lectures, under the auspices of the Boston Chamber of Commerce, to more than 900 people was a notable feature of the work. In all, there were approximately 900 lectures given by members of the faculty during the past year to approximately 66,000 people. Moving-picture apparatus and films should be made a part of our lecture equipment, and a change in the State law should be secured so that the college can use certain types of apparatus without complying with such stringent laws.

Exhibits. — The exhibits in connection with agricultural fairs, and special exhibits, were more systematic and effective than in past years. The general exhibit is now arranged in quite complete separate units, so that these may be used at fruit, dairy, poultry shows or other exhibitions. This year the exhibits were transported from fair to fair by auto truck, thus economizing time and expense. The exhibit was in attendance at the following fairs: Barnstable, Worcester, Clinton, Willimansett, Uxbridge, Framingham, Great Barrington, Northampton and Ware. The period covered was from August 25 to October 9.

The usual number of lectures and demonstrations were carried on in connection with these exhibits. The present exhibit is a good one, but the need seems to be to incorporate more life by means of animals or mechanical contrivances.

Work carried on by State, Smith-Lever and United States Co-operative Demonstration Funds.

Fruit Growing. — The demonstration orchards which were first planted six years ago have been frequently visited, demonstrations have been given, and those who live in the vicinity, as well as the owners of these orchards, have been instructed in the best methods of caring for orchards. A growing interest in these orchards is manifested in communities where they are located.

One new orchard has been established on the farm of Henry L. Green of Paxton. The exhibit material has been enlarged, and the specialist was present for consultation at nine fairs, giving talks and demonstrations. The pomological teaching in the extension schools has been in most cases increased from a half to a full week's work. A pruning and spraying campaign was organized in Shelburne in co-operation with the Franklin County Farm Bureau. This was successful, but could not be carried to other counties on account of lack of time and sufficient force to handle the work. Work in co-operation with the State Board of Agriculture, in connection with the new apple grading and packing law, was carried on. Mr. Rees gave thirty-seven single lectures and demonstrations before various organizations, judged at several fairs, and frequently made farm visits.

Those in charge of this work believe it to be established along right lines, but unless another man can be added to the force it is inadvisable to develop new work the coming year.

The farm bureaus make increased demands for assistance, and during a few weeks in the spring it is not possible to get to all the demonstration orchards for pruning or spraying at the proper time. It is evident that another man is badly needed to help develop work which ought to be carried on in this State.

Publications and Publicity. — Under the Smith-Lever act $500 was allowed for printing and publication. This was supplemented by an apportionment of $900 from State funds, making a total apportionment of $1,400.

Fifty publications, varying from 1 to 40 pages, in editions making a total of 204,200 copies, were printed during the year. In addition to this there were several thousand application blanks, schedules, announcements, posters, etc., issued.

The following is a list of the principal publications for the year: —

12 Facts for Farmers.
9 Primers of Instruction and 1 Account Book for Boys' and Girls' Club Work.
5 Library Leaflets.
3 Massachusetts Bulletin for Farm Women.
4 Market Gardeners' Journal.
2 Cow Record Books.
1 Report of the Extension Service.
1 Extension Bulletin.

Mr. Forbush has regularly sent news letters of approximately 1,200 words each to the daily, weekly and agricultural papers of the State. Fifteen special news letters have been prepared and sent to selected publications. The lectures of the summer school and conference have been abstracted and furnished to the press.

Reliable publications seek material concerning our extension activities. It is to be regretted that the staff is not sufficient to furnish this when it is asked for. This sort of publicity work reaches the people with timely agricultural information, and the college owes it to those who support it to keep them informed as to the opportunities and advantages offered to them.

Animal Husbandry. — The resignation during the year of both the head of the Animal Husbandry Department and the extension specialist makes it difficult to report very specifically, as no report was left by either of the extension work done. The work has continued along the same lines as last year, including dairy improvement association work, extension schools, fair exhibits, milk shows, boys' judging contests, correspondence course work and lectures before granges, breeders' associations and so forth. A special effort has been made to keep in touch with the county agent work, and numerous conferences, farm visits and other advisory work have been done with the county agents and county schools throughout the State.

Boys' and Girls' Club Work. — The general interest in boys' and girls' clubs and junior extension work has continued to grow, and no doubt these activities will have the greatest effect on the future of Massachusetts agriculture of any of the extension work that is being carried on. The potato and corn club work this year has not been so successful as in 1914, while the market garden, poultry and home economics clubs have been better. Canning and pig club work were started this year for the first time, and have proven very satisfactory. This year 69,281 members have been enrolled, as against 42,467 last year. Clubs have been organized in 315 towns, as compared with 269 in 1914.

Mr. E. N. Boland took up his duties as agent in charge of pig club work, Aug. 14, 1915. Between this date and October 10, 211 club members were visited, the object being to teach the scoring of pigs and to help on questions of feeding, care and general management. The interest of boys and girls in this work has always been good, and the parents give much assistance. Boys and girls in the vicinity of Brockton were aided in the securing of pigs by loans of money from the Plymouth County Trust Company of that city. In this way 173 pigs were furnished to those who could not otherwise have had them. Notes were taken from the boys and girls, to be paid with interest at the close of the contest.

The canning and home economics clubs under Miss Nash's direction have been exceptionally well carried on. The third prize winners in State contests were brought to the college for a week in the boys' and girls' camps, the latter being held in 1915 for the first time.

This work needs more support and assistance than we are able to give at the present time. With the present force practically no follow-up work is possible. There should be at least one office assistant, who understands club literature and office management and administration, in addition to the clerical help now provided. There should also be a poultry club man and a general assistant for the field work.

Farm Management Demonstrations. — The farm management demonstration work was carried on under the direction of B. W. Ellis until Feb. 1, 1915, when it was taken over by W. H. Bronson. The work has consisted chiefly in taking farm records, tabulating these and preparing factor sheets, returning these factor sheets in person to the owners of the farms, and following up the suggestions made by visits during the summer; also by fair exhibit work and lectures before various organizations. Areas have been taken for this work in 16 towns in 7 counties. In all, about 800 records have been taken and tabulated, and nearly 500 have been returned to the farmers.

Between February 1 and July 1 Raymond L. Whitney secured 189 records on the onion and tobacco farms of the Connecticut valley. Mr. Bronson has been assisted in this work by four county agents and five agricultural schools. It is planned to survey new areas in 1916, as well as to retake all those which have been surveyed during the past three years. A small circular giving results of this year's work is to be issued. Calls are frequent for a good system of farm-accounting blanks. These should be issued and sold at a nominal price. It is hoped that in a short time a large number of farmers will be able to analyze their own business.

This farm management demonstration work, in our judgment, is the best method we have as yet attempted to use in our efforts to get farmers to reorganize their farm business and place the same on a profitable basis.

Poultry Husbandry. — Practically all the lines of extension work, such as lectures, demonstrations before granges and agricultural societies, agricultural fairs, exhibits and demonstrations, extension schools, conferences, the poultry convention, etc., which were started previous to this year, have been carried on in the usual way. Having taken on a man especially for demonstrational work, we have emphasized two new lines, namely, the testing of hens for bacillary white diarrhœa and the co-operation of local poultry organizations in the way of exhibits. Mr. Alfred G. Lunn took up his duties as extension instructor in poultry husbandry on July 20, 1915.

Home Economics. — The new lines of work started during this year have been the beginning and completion of a three months' project for home management demonstration in the town of Brimfield under the direction of Mrs. Horatio Dresser; the preparation, sending out and return of a questionnaire to follow up the instruction given in extension schools; organization of a correspondence course of ten lessons on foods; the issuing of three "Farm Women" bulletins; the visiting of rural schools which teach home economics or prepare noonday lunches; and the arranging of an extension program to be carried out by the American Home Economics Association. Of the work which had been previously organized, three lines have been strengthened, namely, extension schools, canning demonstrations and boys' and girls' home economics clubs.

The two most urgent needs are: —

1. That a room should be provided on the campus to be used as a kitchen laboratory and general experimental room, in order to test out apparatus, etc., which is to be used in the work.

2. A third person should be employed in order that more extension schools of homemaking may be held; that study groups may be organized in localities where extension schools have been held; that conferences may be had with correspondence study groups; that more home economics club meetings may be attended; that more of the calls for lectures and demonstrations may be met; and that more attention may be given to correspondence courses.

The work of Mrs. Dresser in Brimfield has demonstrated the fact that, provided the right sort of a woman can be secured, it is possible to secure just as good results from home management demonstrations as it is to secure results from farm management demonstrations.

During the year Miss Harriet Hopkins resigned as assistant in the work, and Miss Marie Sayles has been elected to fill her place.

Dairying. — The extension work of the Dairy Department during the past year has consisted principally of the following: —

The organizing of two milk shows — one at Worcester (the largest to date in this country), and the one held annually at Amherst in connection with farmers' week. We co-operated with the Fitchburg milk inspector in an exhibit at the local fair, judged and scored the milk, and sent a representative to answer questions. The dairy section of the fair exhibit was enlarged. A representative of the department made the State institution trip in company with other members of the faculty, and as a result is helping with dairy barn plans at the Massachusetts General Hospital at Waverley. A representative of the department is working on plans, equipment, etc., for a co-operative creamery at Blandford. The Extension Service specialist is secretary of the Massachusetts Creamery Association and the Massachusetts Dairymen's Association. Lectures have been given, slides have been furnished for the use of milk inspectors, five dairy barns have been remodeled under our advice, correspondence courses have been conducted, and assistance has been given in securing dairy legislation. There is need of developing the work more than in the past. Lantern slides or moving-picture films should be prepared. There is call for more work than can be done at present in the fairs and expositions of the State.

Extension Schools. — Ten extension schools in agriculture were held during the year. The attendance was uniformly good and the interest was all that could be asked. It has been necessary to employ during the past year persons outside the regular staff for some work. This evidently detracts from the efficiency of the teaching.

Four extension schools of community planning were held, and it is felt that there will be fine results from these. This work was made more definite this year by the preparation beforehand of syllabi of all talks to be given. The teaching staff of the college co-operated finely in these schools, and it was only through their interest and work that this type of school was made possible.

We very much desire to inaugurate some effective follow-up work to be carried on in all communities where extension schools of either type have been held.

Demonstration Auto Truck. — Demonstration work, using the auto truck as a means of carrying equipment and demonstrator, was continued until Feb. 1, 1915. The growth of county agent work during the year made it unnecessary to continue the work after the resignation of Mr. A. F. MacDougall, who was in charge. The work consisted in visiting towns, calling farmers together in groups and demonstrating proper methods of pruning and spraying fruit trees, packing fruit, operation of dairy machinery, laying out fertilizer demonstration plots, and inducing farmers to keep dairy records and better farm management records.

After February 1, on approval of the Washington authorities, the money which was being spent on this project was placed on the other projects listed in this report.

Extension Work through County and Local Agents. — This includes the report of Mr. B. W. Ellis as assistant State leader.

The farm bureau and county agent work has made remarkable growth during the past year. Prior to Dec. 1, 1914, only one county (Hampden) was organized to the extent of having county agents engaged. During the year Worcester County has organized, with Charles H. White as manager with three assistants; Hampshire County, with A. F. MacDougall as agent; Plymouth County, with Bertram Tupper as agent; Norfolk County, with W. A. Munson as agent; and Franklin County, with John D. Willard as general secretary and Sumner R. Parker as agent. The activities of the Faunce Farm at Sandwich have been broadened so that L. B. Boston, superintendent, acts as county agent for Barnstable County. R. H. Gaskill has been appointed county agent for Bristol County, with headquarters at the County Agricultural School, and H. F. Tompson is acting as district agent in the market-garden district surrounding Boston. F. A. Castle has been acting as district agent for boys' and girls' club work for a group of towns with Framingham as a center. The Hampden County Improvement League now has five paid agents besides its clerical staff.

Berkshire County is nearly ready to call for a man. Probably Essex County will engage a man to act as county agent with headquarters at the County Agricultural School. Middlesex County held one meeting, but decided not to go further with the movement. Seventy-two per cent. of the land area of the State is now under the jurisdiction of farm bureaus and county agents. Co-operative relationships under the general memorandum of understanding with all these county and district organizations have been entered into, and in the main are proving satisfactory excepting in Worcester County. The work in five counties has been placed on a written project basis, with signed projects filed in the extension office.

The State leader or assistant State leader regularly attends the monthly meetings of the county or district organizations. The sum of $1,200, State and Federal funds, is being paid to each county or district organization with which we are co-operating. This amount equals that being contributed from these sources in any other State. Co-operative relationships are also maintained with the State Board of Education through county and local agricultural high schools. This has seemed to be a most satisfactory arrangement, and these local agents have assisted much in the carrying on of farm management demonstration work and in several other lines. Two county schools, one independent school (Smith's), and thirteen teachers of agriculture have worked with us under this arrangement during the past year. The present county agent law is a poor one and should be amended at an early date.

We need to establish at the present time a fair and well-defined working basis between the Extension Service of the college and the United States Department of Agriculture on the one hand, and the county and district organizations on the other. There is a disposition on the part of individuals in some county organizations to accept financial aid, but to deny the privilege of joint supervision of work to be done and expenditure of funds, thus practically blocking any real co-operation.

We believe that the county and district agents should be local representatives of the college and the United States Department of Agriculture; that we should work with and through these agents; and that there should be joint approval by the college and local governing boards of work to be done and of the persons who are to carry on the work after this has once been decided. Only by such a working plan can harmony and efficiency be secured and the whole extension work movement organized on a State and nation wide basis.

Mr. B. W. Ellis resigns as assistant State leader, to take effect Dec. 31, 1915. Mr. Sumner R. Parker has been engaged for this position, his duties to begin Dec. 6, 1915.

Co-operation and Marketing. — This work, carried on under the direction of the Department of Agricultural Economics, has consisted mainly of six types: —

1. General lectures and conferences on markets, co-operation and rural organization.
2. Conferences for the organization of farmers' exchanges.
3. Work with the Massachusetts Development Committee, Bureau of Labor and Unemployment and other organizations.
4. Lectures to granges, farmers' clubs and other organizations.
5. Advice to co-operative exchanges as to organization, general management, etc.
6. Rural credit studies and the giving of information concerning these.

In addition to the foregoing there have been many conferences with market men, railroad officials, county agents and farm bureaus, consumers and producers.

Seven new co-operative exchanges were organized during the past year.

Up to July 1 Mr. Ferguson was employed on half time by the Office of Markets, Washington, D. C., for an investigation of the distribution of milk in Massachusetts. Studies were made in Amherst, Haverhill, Northampton, Pittsfield, Worcester and Springfield. He also rendered valuable assistance to the Boston Chamber of Commerce in the series of meetings which they held in different parts of New England, and in the preparation of the report which is now being circulated. The organization of seventeen co-operative exchanges since the employment of an extension specialist is a significant fact. These in the beginning met with pretty strong opposition on the part of farmers themselves.

The credit plan evolved by Mr. Ferguson met with the approval of the bankers of Hampden County, farmers and the United States Department of Agriculture. There is need of doing definite research work in marketing lines especially, and some arrangements should be made during the coming year with the experiment station, so that the Extension Service specialist in this subject may spend part time in gathering information and the remainder in the organizing of buying and selling societies.

Work carried on alone by the United States Department of Agriculture Co-operative Demonstration Funds.

Hog Cholera. — Dr. D. I. Skidmore, who was assigned by the Bureau of Animal Industry, United States Department of Agriculture, for demonstration work in the prevention of hog cholera, was withdrawn from the State at the time of the outbreak of the foot and mouth disease to help in eradicating this. The unforeseen expense of this work has made it impossible for the Department to reassign him to us to continue this work, so that little has been done on the project during the year.

Temporary Projects, not in Force after July 1, 1915, carried on by State, Smith-Lever and the United States Department of Agriculture Co-operative Demonstration Funds co-operatively.

Gardner Boyd was engaged as temporary assistant in club work, Raymond Whitney for farm management demonstrations, Mrs. Horatio Dresser for home management demonstrations, F. A. Castle for club work in the district surrounding Framingham, H. F. Tompson for market-garden demonstrations, and three senior students as demonstrators to assist county agents in the crowded season of work. This work was financed from unexpended balances of Smith-Lever money and from funds assigned by the Office of Extension Work at Washington. The projects were all discontinued July 1, 1915. Reports of the work which was carried on will be found under the proper departments in this report.

Recommendations.

There are many recommendations which might be made by the director, few of which can be carried out with no more State funds at hand than we had three years ago.

It is a discouraging proposition to have two or three times as many calls for help coming in from earnest people as can be cared for. The members of the faculty of the college are anxious to do more extension work, but funds for this cannot be provided.

The present fixed appropriation is still to run three full years. Before the end of that period the trustees must face the problem of curtailing or abolishing some lines now in force, or providing some financial relief. It is clear that the Extension Service will suffer badly if we cannot increase salaries sufficiently to keep tried and proven members of our staff with us. The advent of farm bureau work makes it necessary for us to engage a few highly trained specialists rather than a large number of inexperienced demonstrators. In this way we can give county agents the assistance in special lines which they so much need.

We must certainly hold strictly to a program of concentration rather than expansion.

I would recommend that a change of law be secured so that a report of the Extension Service may be printed at State expense, in the same way as the station report is now handled.

A full report of statistics and a financial statement will be rendered as a part of a more complete annual report as now required by the Smith-Lever law as soon after the 1st of December as these figures can be secured.

So far as the need of more persons to do extension work is concerned, I can do no better than to reiterate what was said in the biennial report published some months ago, slightly modified. This is as follows: —

1. With an appropriation already fixed for the next three years by the State, and the fact that, due to the reasons already stated, Massachusetts receives but $2,440 additional each year from Smith-Lever bill funds, no enlargement or expansion of extension activities can be expected. The most that we should try to do is to retain if possible our present excellent force of extension workers, and to perfect within the institution itself a better working organization.

2. There is an urgent need for the adoption by the trustees of a definite policy defining what the extension work of the institution should be, and the relation of all employees of the college to it. The director suggests that the following definition might be used on which to base the policy: "The Extension Service is the whole institution (every department and individual) at work doing what it can to upbuild the rural life of the Commonwealth, and all employees are expected, in so far as extension work does not interfere with their teaching or research work, to take their part in this movement, and to make themselves and their departments as useful as is possible in the different movements to build up the agricultural industry of the State."

3. While there is probably no chance of our meeting any of the immediate needs for more help, yet these should nevertheless be presented. There are organizations such as the poultrymen, those interested in boys' and girls' club work, and the market gardeners, who are willing to go before the Legislature and secure funds to carry on the work which they wish done. It would seem that under such circumstances no objection should be raised by the college.

So far as demands for help and assistance are concerned, plans might be made to expend profitably at least $50,000 in addition to what is now being appropriated. Existing conditions, however, must be considered, and only the most urgent needs are here mentioned.

(*a*) Extension instructor in market gardening: —		
Salary,	$2,000 00	
Travel,	500 00	
Supplies and equipment,	200 00	
		$2,700 00

(*b*) Extension worker in poultry husbandry: —		
Salary,	$1,800 00	
Travel,	500 00	
Supplies and equipment,	200 00	
		$2,500 00
(*c*) Extension workers, boys' and girls' clubs (United States Department of Agriculture might pay one-half salary and expenses): —		
Salaries of supervisors (4),	$5,400 00	
Travel (4),	2,000 00	
Supplies and equipment,	600 00	
		8,000 00
(*d*) Extension instructor in agronomy: —		
Salary instructor,	$1,800 00	
Travel,	500 00	
Supplies and equipment,	200 00	
		2,500 00
(*e*) Extension instructor in fruit growing: —		
Salary instructor,	$1,500 00	
Travel,	500 00	
Equipment,	100 00	
		2,100 00
(*f*) Extension worker in farm management demonstrations (United States Department of Agriculture might pay one-half salary and expenses): —		
Salary,	$1,500 00	
Travel,	700 00	
Equipment,	100 00	
		2,300 00
(*g*) Extension instructor in home economics: —		
Salary,	$1,200 00	
Travel,	500 00	
Equipment,	100 00	
		1,800 00
(*h*) Adviser and demonstrator to work with State institutions: —		
Salary,	$3,000 00	
Travel,	700 00	
		3,700 00
(*i*) Extension instructor, injurious insects and plant diseases: —		
Salary,	$1,800 00	
Travel,	500 00	
Equipment,	200 00	
		2,500 00

(*j*) Extension instructor in agricultural engineering: —		
Salary,	$2,000 00	
Travel,	500 00	
Equipment,	200 00	
		$2,700 00
(*k*) Extension assistant in beekeeping (part time),		1,200 00
(*l*) Clerical assistance and office equipment required for above additional force,		6,000 00
Total,		$38,000 00

4. Since the college receives for instructional purposes an automatic increase in its funds, the cost of running the short courses (approximately $8,500) might be paid from these funds, thus relieving the extension budget to that extent. Some of this much needed work might then be started.

The director has every reason to commend in the highest terms all members of the Extension Service staff and those members of the college faculty and station staff who continue to offer such fine co-operation in the attempt to make this college a "public service institution." They render an unselfish service which cannot be fairly reckoned on a financial basis.

Wm. D. Hurd,
Director.

TABLES AND STATISTICS.

TABLE I. — *New Appointments.*

A. In the Academic Departments.

POSITION.	Name.	Institution from which graduated and Degrees.
Instructor in botany,[1]	Paul J. Anderson,	A.B., Wabash College, 1910; Ph.D., Cornell University, 1914.
Professor of military science,	Henry W. Fleet,	Culver Military Academy.
Assistant in microbiology,[1]	Arao Itano,	Michigan Agricultural College, B.Sc., 1911.
Assistant professor of dairying,[1]	Orville A. Jamison,	Ohio State University, B.Sc., 1912.
Assistant professor of agronomy,	Earl Jones,	Ohio State University, B.Sc., 1912; M.Sc., 1913.
Professor of animal husbandry,[2]	John C. McNutt,	Ohio State University, B.Sc., Agr., 1907.
Assistant in agronomy,[1]	Frederick G. Merkle,	Massachusetts Agricultural College, B.Sc., 1914.
Instructor in farm management,[1]	Walter M. Peacock,	Cornell University, B.Sc., 1913; M.Sc., 1915.
Professor of rural sociology,	John Phelan,	University of Michigan, A.B., 1910; A.M., 1912.
Assistant in agricultural economics,[1, 3]	Frederick W. Read,	Massachusetts Agricultural College, B.Sc., 1914.
Assistant in chemistry,	Paul Serex, Jr.,	Massachusetts Agricultural College, B.Sc., 1913.
Assistant to the commandant,[1]	Alexander Smart,	- - -
Assistant professor of horticulture,[1]	Charles H. Thompson,	Kansas State Agricultural College, B.Sc., 1893; M.Sc., 1898.
Assistant in physics,[1]	Harry C. Thompson,	Worcester Polytechnic Institute, B.Sc., 1915.
Assistant professor of market gardening.[1]	Andrew S. Thomson,	Brown University, Ph.B., 1898; Columbia University, A.M., 1912.
Professor of market gardening,	Harold F. Tompson,	Massachusetts Agricultural College, B.Sc., 1905.
Instructor in animal husbandry,[4]	Glenn J. Wight,	Cornell University, B.Sc., 1914.

B. In the Experiment Station.

Assistant chemist,[5]	Norman H. Borden,	Rhode Island State College, B.Sc., 1915.
Assistant,	Robert L. Coffin,	Coburn Classical Institute, 1907.
Assistant in veterinary science,[1]	Beryl H. Paige,	Mount Holyoke College, A.B., 1911.
Assistant in veterinary science,[1]	Arnold P. Sturtevant,	Clark College, A.B., 1912.

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[1] New position.

[2] Services to begin Jan. 1, 1916.

[3] Services to begin Feb. 1, 1916.

[4] Temporary engagement.

[5] Temporary appointment during leave of absence of Mr. R. W. Ruprecht.

C. In the Extension Service.

POSITION.	Name.	Institution from which graduated and Degrees.
Extension instructor in charge of boys' and girls' pig club work.[1]	Eric N. Boland, .	Massachusetts Agricultural College, B.Sc., 1912; Iowa State College, M.Sc., 1913.
Instructor in farm management demonstrations.	Wesley H. Bronson, .	Cornell University, B.Sc., 1913.
Extension instructor in poultry husbandry.[1]	Alfred G. Lunn, .	Oregon Agricultural College, B.Sc.Agr., 1912.
Assistant State leader, ...	Sumner R. Parker, .	Massachusetts Agricultural College, B.Sc., 1904.
Extension instructor in home economics,	Marie Sayles, . .	Kalamazoo Normal School; Columbia University, Teachers' College, B.Sc., 1914.
Extension instructor in animal husbandry.[2]	William F. Turner, .	Kansas State Agricultural College, B.Sc., Agr., 1910.

[1] New position.

[2] Services to begin December, 1915.

D. In the Clerical Staff.

POSITION.	Name.
Clerk, treasurer's office, ...	Eleanor F. Bishop.
Cashier, treasurer's office, ...	John K. Broadfoot.
Clerk, president's office, ...	Bertha A. Brockhaus.
Assistant in library, ...	Anne Butler.
Stenographer, Department of Agricultural Education, . . .	Phyllis J. Cogswell.
Clerk, Department of Poultry Husbandry, ...	Marcella C. Curry.
Telephone operator, Stockbridge Hall,[1]	Louise G. Davidson.
Clerk, director's office, experiment station, ...	F. Ethel Felton.
Clerk, Extension Service,[1]	Lillian S. Hadfield.
Clerk, Department of Rural Sociology,[1], [2]	Mary E. Horton.
Stenographer, Extension Service, ...	Helena Keiber.
Stenographer, treasurer's office, ...	Irene A. Martin.
Clerk, dean's office, ...	Mary I. Shores.

E. Miscellaneous.

Assistant engineer, ...	Thomas F. Butterworth.
Resident nurse,[1]	Florence Levensaler.

[1] New position.

[2] Transferred from president's office.

TABLE II. — *Resignations.*

POSITION.	Name.
Assistant in library,	Clarissa G. Babcock.
Extension instructor in farm management and assistant State leader,	Herbert J. Baker.
Instructor in chemistry,	Robert H. Bogue.
Assistant in library,	Anne Butler.
Cashier, treasurer's office,	Mary E. Caldwell.
Assistant to the dean,	Bertha E. Christiansen.
Stenographer, Department of Agricultural Education,	Marion S. Donaldson.
Assistant State leader,[1]	Benjamin W. Ellis.
Extension instructor in civic improvement,	Philip H. Elwood, Jr.
Assistant chemist, experiment station,	Walter S. Frost.
Extension instructor in home economics,	Harriet J. Hopkins.
Assistant professor of agronomy,	Elmer M. McDonald.
Extension instructor in charge of demonstration auto truck,	Allister F. McDougall.
Associate professor of animal husbandry,	John A. McLean.
Professor of military science and tactics,[2]	George C. Martin.
Clerk, Department of Poultry Husbandry,	Fay L. Milton.
Stenographer, Extension Service,	Ina M. Paige.
Clerk, treasurer's office,	Luther R. Putney.
Assistant engineer,	Percy C. Schroyer.
Stenographer, Department of Agricultural Economics,	Harriet C. Stevenson.
Extension instructor in animal husbandry,	George F. E. Story.
Stenographer, treasurer's office,	Dorothy Tyacke.

[1] Resignation to take effect Dec. 31, 1915.
[2] Relieved from duty by United States War Department.

TABLE III. — *Change in Title of Officers of the Institution.*

NAME.	Former Title.	Present Title.
Paul J. Anderson,	Instructor in botany,	Assistant professor of botany.
Edgar L. Ashley,	Assistant professor of German,	Associate professor of German.
Harold D. Baldinger,	Assistant in dairying,	Instructor in dairying.
Alexander E. Cance,	Associate professor of agricultural economics.	Professor of agricultural economics.
Walter W. Chenoweth,	Assistant professor of pomology,	Associate professor of pomology.
Guy C. Crampton,	Associate professor of entomology.	Professor of insect morphology.
Benjamin W. Ellis,	Extension instructor in farm demonstration.	Assistant State leader.
Lina E. Fisher,	Stenographer, Department of Chemistry.	Clerk, Department of Chemistry.

TABLE III. — *Change in Title of Officers of the Institution* — Concluded.

NAME.	Former Title.	Present Title.
Grace E. Gallond,	Stenographer, experiment station.	Clerk, Department of Dairying.
Alice M. Gilbert,	Clerk, Department of Dairying,	First clerk, Division of Agriculture.
Christian I. Gunness,	Associate professor of rural engineering.	Professor of rural engineering.
Sidney B. Haskell,	Associate professor of agronomy,	Professor of agronomy.
Lorian P. Jefferson,	Expert secretary, Division of Rural Social Science.	Research secretary, Division of Rural Social Science.
Anderson A. Mackimmie,	Assistant professor of French,	Associate professor of French.
Walter E. Prince,	Instructor in English,	Assistant professor of English.
William S. Regan,	Assistant in entomology,	Instructor in entomology.

TABLE IV. — *Speakers for the Year.*

A. *Speakers at Wednesday Assembly for Year ending Nov. 30, 1915.*

1914.
Dec. 2. — Pres. Kenyon L. Butterfield.
Dec. 9. — Prof. William L. Machmer, M. A. C.
Dec. 16. — Mr. Jewell B. Knight, M. A. C., 1892, Poona, India.

1915.
Jan. 6. — Memorial service in memory of Dean George F. Mills.
Jan. 13. — Mr. Albert Blair, Brooklyn, N. Y.
Jan. 20. — Mr. Warren P. Landers, Boston.
Feb. 3. — Dr. David Snedden, Boston, Massachusetts Commissioner of Education.
Feb. 10. — Prof. E. L. Morgan, M. A. C.
Feb. 17. — Prof. Frank A. Updyke, Dartmouth College.
Feb. 24. — Pres. Kenyon L. Butterfield.
Mar. 3. — Prof. Frank A. Waugh, M. A. C.
Mar. 10. — Dean Edward M. Lewis, M. A. C.
Apr. 7. — Pres. Kenyon L. Butterfield.
Apr. 14. — Mr. John D. Willard, Greenfield, Mass.
Apr. 28. — Hon. Charles M. Gardner, Westfield, Mass.
May 5. — Mr. Samuel Gompers, Washington, D. C.
May 12. — Mr. George D. Leavens, M. A. C., 1897, New York City.
May 19. — Prof. Robert J. Sprague, M. A. C.
May 26. — Pres. Kenyon L. Butterfield.
Sept. 22. — Pres. Kenyon L. Butterfield.
Sept. 29. — Dean Edward M. Lewis, M. A. C.
Oct. 6. — Pres. Kenyon L. Butterfield.
Oct. 13. — Student forum.
Oct. 20. — Prof. Walton H. Hamilton, Amherst College.
Oct. 27. — Chancellor David Starr Jordan, Leland Stanford University.
Nov. 3. — Pres. Kenyon L. Butterfield.
Nov. 10. — Rev. Lyman Abbott, D.D., New York City.

B. *Speakers at Sunday Chapel for Year ending Nov. 30, 1915.*

1914.
Dec. 6. — Rev. Jason N. Pierce, Dorchester, Mass.
Dec. 13. — Rev. William I. Chamberlain, New York City.

1915.
Jan. 10. — Rev. Arthur C. Baldwin, Boston.
Jan. 17. — Bishop John W. Hamilton, Boston.

1915.
Jan. 24. — Rev. Neil McPherson, Springfield.
Feb. 7. — Rev. Fleming James, Englewood, N. J.
Feb. 14. — Dr. Frederick Lynch, New York City.
Feb. 21. — Dr. Charles Fleischer, Boston.
Feb. 28. — Rev. George Hodges, D.D., Newton, Mass.
Mar. 7. — Rev. Frank M. Sheldon, Boston.
Mar. 14. — Mr. Charles D. Hurrey, New York City.
Mar. 21. — Rev. John W. Hoag, New Haven, Conn.
Apr. 11. — Rev. Carl S. Patton, Columbus, O.
Apr. 18. — Mr. Owen R. Lovejoy, New York City.
Oct. 3. — Pres. Kenyon L. Butterfield.
Nov. 7. — Hon. William H. Taft, New Haven, Conn.
Nov. 14. — Rev. Samuel A. Eliot, Boston.
Nov. 21. — Rev. Albert P. Fitch, D.D., Cambridge, Mass.

Table V. — *Attendance.*

A. In Work of College Grade.

	Registration Nov. 30, 1914.	Registration Nov. 30, 1915.
Senior class,	103	108
Junior class,	113	110
Sophomore class,	142	162
Freshman class,	168	211
	526	591
Graduate students,	52	52
Unclassified students,	32	25
Total doing work of college grade,	610	668

B. Short-course Enrollment and Convention Registration.

	1914.	**1915.**
Winter school,	182	182
Summer school,	146	162
Apple-packing school,	30	19
School for tree wardens,	22	–
Farmers' week,	1,563	–
School for rural social service,	22	14
School for library workers,	–	25
Boys' camps,	47	92
Girls' camps,	–	13
Polish farmers' day,	86	–
Poultry convention,	586	600
Conference on rural community planning,	329	261
Convention of county agents and agricultural instructors,	28	38
Total,	3,041	1,406

Table VI. — *Legislative Budget, 1915.*

Items.	Amount asked.	Amount granted.
Special appropriations: —		
Addition to the power plant,	$30,000	$10,000
Miscellaneous additions,	10,000	–
Student dormitory,	40,000	–
Laboratory for microbiology,	67,500	67,500
	$147,500	$77,500

There was also submitted a bill requesting an appropriation of $200,000 a year for six years for buildings and other improvements; this request was not granted.

Table VII. — *Statistics of Freshmen entering Massachusetts Agricultural College, September, 1915.*

A. *Home Addresses of Students (classified by Towns and Cities).*

Acushnet,	1
Amesbury,	1
Amherst,	5
Arlington,	3
Atlanta, Ga.,	1
Avon,	1
Ayer,	1
Baltimore, Md.,	1
Barnstable,	1
Beverly,	1
Boston,	19
Bourne,	1
Braintree,	2
Brimfield,	1
Brockton,	1
Brookline,	2
Cambridge,	3
Chester,	1
Chester, Pa.,	1
Chesterfield,	1
Colrain,	1
Danvers,	1
Darien, Conn.,	1
Dedham,	1
Deerfield,	2
Durham, Conn.,	1
East Orange, N. J.,	2
Everett,	1
Fall River,	2
Falmouth,	1
Fitchburg,	1
Framingham,	3
Great Barrington,	2
Greenfield,	3
Groton,	2
Hammonton, N. J.,	1
Hanover,	1
Havana, Cuba,	1
Haverhill,	2
Hingham,	1
Holliston,	1
Hopedale,	1
Hudson,	1
Kensington, Conn.,	1
Lakeville,	1
Leominster,	3
Leverett,	1
Lima, N. Y.,	1
Longmeadow,	1
Lynn,	8
Malden,	3
Marion,	1
Melrose,	8
Mendon,	1
Merrimac,	1
Methuen,	1
Milford,	4
Milton,	1
Monson,	1
Montague,	1
Millville, N. J.,	1
Nantucket,	1
Needham,	1
New Bedford,	1
Newburyport,	1
New Canaan, Conn.,	1
New Marlborough,	1
Newton,	5
Newtown, Conn.,	1
Northampton,	4
North Attleborough,	1
Northbridge,	1
North Reading,	1
Norwich, Conn.,	1
Orange,	1
Orleans,	1
Oxford,	1
Paterson, N. J.,	1
Pittsfield,	1
Plainville,	1
Portland, Me.,	1
Proctor, Vt.,	1
Providence, R. I.,	2
Putnam, Conn.,	1
Quincy,	4
Randolph,	1
Reading,	1
Richmond Hill, N. Y.,	1
Rockfall, Conn.,	1
Rockland,	3
Schenevus, N. Y.,	1
Sharon,	2
Shelburne,	1
Sherborn,	1
Somerville,	9
Southbridge,	1
Springfield,	6
Suffield, Conn.,	1
Sunderland,	2
Taunton,	1
Tolland,	1
Topsfield,	1
Townsend,	1
Troy, N. Y.,	1
Upton,	1
Uxbridge,	1
Waltham,	2
Warren,	2
Wenham,	1
Westfield,	2
West Springfield,	2
Weymouth,	3
Williamstown,	1
Wilson, Conn.,	1
Winchendon,	1
Winchester,	1
Worcester,	2

B. Home Addresses (classified by States).

	Number.	Per Cent.		Number.	Per Cent.
Connecticut,	11	5.21	New York,	4	1.90
Georgia,	1	.47	Pennsylvania,	1	.47
Maine,	1	.47	Rhode Island,	2	.95
Maryland,	1	.47	Vermont,	1	.47
Massachusetts,	183	86.73	Cuba,	1	.47
New Jersey,	5	2.37		211	99.98

C. Home Addresses (classified by Counties of Massachusetts).

	Number.	Per Cent.		Number.	Per Cent.
Barnstable,	3	1.64	Middlesex,	47	25.68
Berkshire,	5	2.73	Nantucket,	1	.55
Bristol,	6	3.28	Norfolk,	19	10.38
Essex,	18	9.83	Plymouth,	8	4.37
Franklin,	12	6.56	Suffolk,	19	10.38
Hampden,	15	8.20	Worcester,	20	10.93
Hampshire,	10	5.46		183	99.99

D. Nativity of Parents.

	Number.	Per Cent.
Neither parent foreign born,	158	74.88
Both parents foreign born,	32	15.17
Father (only) foreign born,	16	7.58
Mother (only) foreign born,	5	2.37
	211	100.00

E. Education of Father.

	Number.	Per Cent.
Common school,	93	44.08
High school,	61	28.91
Business school,	20	9.48
College or university,	35	16.59
No statistics,	2	.95
	211	100.01

F. *Religious Census.*

	Membership.		Preference.		Totals.	
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.
Baptist,	16	7.58	7	3.32	23	10.90
Catholic,	25	11.85	2	.95	27	12.80
Congregationalist,	54	25.59	23	10.90	77	36.49
Episcopal,	14	6.63	2	.95	16	7.58
Hebrew,	4	1.89	1	.47	5	2.37
Methodist,	18	8.53	9	4.27	27	12.80
Presbyterian,	3	1.42	1	.47	4	1.89
Unitarian,	7	3.32	4	1.89	11	5.21
Universalist,	2	.95	3	1.42	5	2.37
Miscellaneous,	7	3.32	7	3.32	14	6.63
	150	71.09	59	27.96	209	99.05
No statistics,	–	–	–	–	2	.95
	150	71.09	59	27.96	211	100.00

G. *Occupation of Father.*

	Number.	Per Cent.
Agriculture and horticulture,	33	15.64
Artisans,	50	23.70
Business,	61	28.91
Deceased or no statistics,	19	9.00
Miscellaneous,	21	9.95
Professional,	26	12.31
Retired,	1	.47
	211	99.98

H. *Intended Vocation of Student.*

	Number.	Per Cent.
Agriculture or horticulture (practical),	98	46.45
Agriculture or horticulture (professional),	69	32.70
Miscellaneous,	1	.47
Professions,	5	2.37
Undecided or no statistics,	38	18.01
	211	100.00

I. Farm Experience.

	Number.	Per Cent.
Brought up on a farm,	51	24.17
Not brought up on a farm, and having had no, or practically no, farm experience.	75	35.55
Not brought up on a farm, but having had some farm experience.	85	40.28
	211	100.00

J. Miscellaneous Statistics.

Average age,	19.15 years.
Number signifying their intention to seek student labor,	130 (61.61 per cent.)
Number boarding at the college dining hall,	165 (78.20 per cent.)

Table VIII. — *Entrance Statistics of Freshman Class.*

Number of applications,			411
Admitted,		239	
Matriculated,	211		
Failed to report,	28		
Total,		239	
Rejected,		172	
Total,			411
Matriculated on certificate,			92
Matriculated on examination,			23
Matriculated on certificate and examination,			83
Matriculated on credentials from another college,			6
Re-entered,			7
			211
Matriculated without condition,			129
Matriculated with condition,			82
			211

Table IX. — *Official Visits by Outside Organizations.*

Connecticut Valley Breeders' Association.
Massachusetts State Poultry Association, Inc.
Massachusetts Poultry Society.
Massachusetts Federation for Rural Progress.
Massachusetts Agricultural Development Committee.
Massachusetts Homestead Commission.
Massachusetts Committee on Rural Resources.
Massachusetts Collegiate Country Life Club.
Rural Church Committee of the Congregational Church.
The Northampton and Holyoke Gardeners' and Florists' Club.
Vocational Agricultural Instructors.

TABLE X. — *Cases treated at the Infirmary, Sept. 15 to Nov. 30, 1915.*

September 15 to October 1: —	
House cases,	19
Out-patients,	4
October 1 to November 1: —	
House cases,	72
Out-patients,	48
November 1 to December 1: —	
House cases,	26
Out-patients,	36
Number of house cases,	117
Number of out-patients,	88
Total,	205
Number cared for in the house,	19
Number cared for as out-patients,	37
Total,	56

REPORT OF THE TREASURER

FOR THE FISCAL YEAR ENDING NOV. 30, 1915.

BALANCE SHEET.

		DR.	CR.
1914. Dec. 1.	To balance on hand,	$44,255 00	
1915. Nov. 30.	To receipts for fiscal year,	728,188 79	
	Expenditures for fiscal year,		$719,304 72
	Balance on hand,		53,139 07
		$772,443 79	$772,443 79

SCHEDULE A. — INCOME.

		Items.	Totals.
Income from students and others,		. . .	$85,998 51
Tuition fees,		$3,479 00	
Laboratory fees,		5,648 50	
Rents,		5,833 26	
Department sales,		58,716 52	
Department transfers,		6,225 98	
Miscellaneous,		6,095 25	
Income from grants by nation and State: —			
State aid,		. . .	527,093 17
Income from endowment,		$3,313 32	
Appropriation for current expenses,		228,000 00	
Administration,	$31,000 00		
Maintenance,	90,000 00		
Instruction,	90,000 00		
Graduate school,	2,000 00		
Improvements,	10,000 00		
Additional land,	5,000 00		
Appropriation for extension service,		50,000 00	
Appropriation for experiment station,		31,000 00	
Maintenance,	$25,000 00		
Feed law,	6,000 00		
Receipts from special appropriation,		214,779 85	
Federal aid,		. . .	82,098 70
Income from land grant of 1862,		$7,300 00	
Income from Hatch fund of 1887,		15,000 00	
Income from Adams fund of 1906,		15,000 00	
Income from Nelson fund of 1907,		16,666 67	
Income from Morrill fund of 1890,		16,666 66	
Income from Smith-Lever fund of 1914,		11,465 37	

SCHEDULE A. — INCOME — *Concluded.*

	Items.	Totals.
Income from other sources: —		
Income from experiment station,	. . .	$26,969 31
Fertilizer receipts,	$10,088 00	
Agricultural receipts,	2,365 01	
Cranberry receipts,	2,437 01	
Chemical receipts,	10,732 09	
Miscellaneous receipts,	1,347 20	
Income from extension service,	. . .	6,029 10
Winter school receipts,	$1,095 50	
Summer school receipts,	1,748 01	
Correspondence course receipts,	655 67	
Itinerary instruction receipts,	840 88	
Miscellaneous receipts,	1,689 04	
Total,	. . .	$728,188 79

CLASSIFICATION OF INCOME FROM STUDENTS AND OTHERS.

	Laboratory Fees.	Department Sales.	Transfers.	Rent.	Income.	Miscellaneous.	Tuition.	Totals.
Agricultural economics,	-	$17 25	-	-	-	-	-	$17 25
Agricultural education,	-	96	-	-	-	-	-	96
Agronomy,	$411 00	-	-	-	-	$100 00	-	511 00
Animal husbandry,	180 00	-	-	-	-	100 00	-	280 00
Beekeeping,	-	97 09	$6 70	-	-	-	-	103 79
Botany,	632 00	42 48	-	-	-	-	-	674 48
Chemistry,	2,883 00	57 56	20 72	-	-	-	-	2,961 28
Dairy,	112 00	17,867 38	617 20	-	-	100 00	-	18,696 58
Entomology,	110 50	3 56	-	-	-	-	-	114 06
Farm administration,	-	27 88	50	-	-	-	-	28 38
Floriculture,	-	2,951 36	35 84	-	-	100 00	-	3,087 20
Farm,	-	30,313 09	1,672 32	-	-	-	-	31,985 41
Forestry,	-	9 00	58 40	-	-	100 00	-	167 40
General horticulture,	-	31 57	3,464 23	-	-	323 50	-	3,819 30
Grounds,	-	507 70	-	-	-	-	-	507 70
Hospital,	-	-	-	-	-	30 77	-	30 77
Landscape gardening,	297 00	14 92	4 12	-	-	100 00	-	416 04
Language and literature,	-	40	-	-	-	-	-	40
Library,	-	174 58	16 04	-	$417 09	-	-	607 71
Market gardening,	-	1,276 31	111 34	-	-	100 00	-	1,487 65
Mathematics,	72 00	-	18 00	-	-	-	-	90 00
Microbiology,	345 00	-	45 80	-	-	59 36	-	450 16
Military,	-	-	5 90	-	-	-	-	5 90
Physics,	-	93	-	-	-	-	-	93
Pomology,	137 50	1,540 27	27 95	-	-	100 00	-	1,805 72
Physical education,	-	1 25	-	-	-	-	-	1 25
Poultry husbandry,	90 50	3,372 24	7 23	-	-	100 93	-	3,570 90
Rural engineering,	-	-	6 56	-	-	100 00	-	106 56
Rural sociology,	-	1 40	-	-	-	-	-	1 40
Veterinary,	-	-	27 13	-	-	-	-	27 13
Zoölogy and geology,	378 00	34 00	2 75	-	-	-	-	414 75
Operating and maintenance,	-	-	7 60	-	-	4,214 75	$3,479 00	7,701 35
North dormitory,	-	-	-	$2,006 49	-	-	-	2,006 49
South dormitory,	-	-	69 10	2,435 35	-	-	-	2,504 45
College residences,	-	-	-	569 56	-	-	-	569 56
Executive order,	-	-	-	-	-	48 85	-	48 85
President's office,	-	-	55	-	-	-	-	55
Salaries,	-	-	373 34	-	-	-	-	373 34
Draper hall,	-	-	-	821 86	-	-	-	821 86
Totals,	$5,648 50	$58,343 18	$6,599 32	$5,833 26	$417 09	$5,678 16	$3,479 00	$85,998 51

Schedule B. — Expenditures for Fiscal Year.

	Items.	Totals.
College expenses,	. . .	$342,659 93
Administration,	$31,381 32	
Maintenance,	179,714 94	
Instruction,	131,563 67	
Experiment station,	. . .	88,178 87
Administration,	$1,011 28	
Feed inspection,	5,337 54	
Fertilizer law,	10,047 01	
Salaries,	39,199 74	
Departments,	32,583 30	
Extension service,[1]	. . .	64,486 07
Salaries,	$36,215 97	
Travel,	9,677 21	
Departments,	18,592 89	
Special appropriation,	. . .	223,636 67
Infirmary,	$13,052 48	
Agricultural building,	176,629 92	
Sewers,	9,200 00	
Addition to power plant,	10,000 00	
Microbiology building,	14,754 27	
Miscellaneous,	. . .	343 18
Total,	. . .	$719,304 72

[1] Made up from State Extension Service and Smith-Lever funds.

ANALYSIS OF COLLEGE EXPENDITURES.

ADMINISTRATION.	Office Expense.	Salaries and Labor.	Travel.	Minor Equipment.	Building Supplies.	Publicity and Lectures.	Student Activity.	Commencement.	Miscellaneous.	Totals.
Dean's office,	$158 19	$290 25	–	$37 60	–	–	–	–	–	$486 04
Executive order,	–	–	$1,932 48	–	–	$1,197 84	$1,102 03	$502 17	$3,180 82	7,915 34
President's office,	728 88	154 95	49 85	–	$4 31	–	–	–	–	937 99
Registrar's office,	373 27	95 35	40 49	5 17	–	–	–	–	–	514 28
Treasurer's office,	649 84	541 18	145 25	8 43	2 47	–	–	–	72 29	1,419 46
Administration (salaries),	–	20,108 21	–	–	–	–	–	–	–	20,108 21
Totals,	$1,910 18	$21,189 94	$2,168 07	$51 20	$6 78	$1,197 84	$1,102 03	$502 17	$3,253 11	$31,381 32

MAINTENANCE.	Office Supplies.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Miscellaneous.	Salaries.	Totals.
Academic maintenance: —											
Agricultural economics,	$117 98	$17 48	$5 23	–	$9 21	–	$14 55	–	–	–	$164 45
Agricultural education,	156 45	160 35	95 98	–	2 50	–	92 10	–	$0 73	–	508 11
Agronomy,	76 32	99 08	201 26	$17 50	23 52	–	28 12	–	–	–	445 80
Animal husbandry,	133 28	138 46	114 33	5 00	32 83	–	119 85	–	–	–	543 75
Beekeeping,	141 13	998 55	223 77	–	134 63	$95 21	4 00	–	–	–	1,597 29
Botany,	146 11	457 00	644 43	41 00	31 75	49 62	16 15	–	–	–	1,386 06
Chemistry,	196 65	1,027 95	2,616 77	647 57	79 13	92 98	–	–	–	–	4,661 05
Dairying,	151 92	1,586 38	19,642 11	28 26	327 32	105 66	75 76	–	–	–	21,917 41
Economics and sociology,	22 66	–	13 74	–	–	–	–	–	–	–	36 40
Entomology,	30 01	300 17	199 76	6 00	45 17	117 12	34 47	–	–	–	732 70
Farm administration,	144 05	286 16	50 54	–	49 91	34 24	20 21	–	–	–	585 11
Floriculture,	120 01	3,037 63	1,202 10	–	65 32	144 97	99 05	–	–	–	4,669 08
Forestry,	80 42	81 59	75 05	–	24 57	–	66 09	–	–	–	327 72
History and government,	5 27	–	–	–	–	–	–	–	–	–	5 27
Hospital,	–	–	–	–	–	–	–	$741 11	–	–	741 11
Landscape gardening,	65 63	16 52	327 30	2 50	13 93	–	20 47	–	–	–	446 35

ANALYSIS OF COLLEGE EXPENDITURES — *Concluded.*

MAINTENANCE.	Office Supplies.	Labor.	Laboratory Supplies.	Refunds.	Minor Equipment.	Building Supplies.	Travel.	General Expense.	Miscellaneous.	Salaries.	Totals.
Language and literature,	$33 96	$84 00	$40 71	–	$11 13	–	–	–	–	–	$169 80
Market gardening,	64 00	2,864 24	594 43	–	14 83	$27 51	$79 90	–	–	–	3,644 91
Mathematics,	49 10	96 62	98 82	$9 99	–	9 13	–	–	–	–	263 66
Microbiology,	125 02	214 80	227 38	90 91	22 86	10 29	–	–	–	–	691 26
Military science,	225 20	524 29	12 00	–	212 38	25 35	–	–	$311 26	–	1,310 48
Physical education,	150 59	182 08	112 73	–	190 00	15 34	271 95	–	–	–	922 69
Physics,	88 90	253 68	182 00	–	49 07	12 73	–	–	–	–	586 38
Pomology,	104 68	2,383 35	865 41	1 50	95 13	–	22 47	–	–	–	3,472 54
Poultry husbandry,	376 51	1,399 36	4,306 39	7 50	137 39	141 63	36 50	–	–	–	6,405 28
Rural engineering,	26 81	113 64	137 01	–	176 42	–	8 10	–	–	–	461 98
Rural sociology,	54 79	–	3 82	–	29 09	–	6 30	–	–	–	94 00
Veterinary science,	34 68	326 71	688 01	–	110 42	75 84	–	–	–	–	1,235 66
Zoölogy and geology,	22 62	220 40	353 75	13 50	114 12	–	50 37	–	–	–	774 76
General maintenance: —											
Equipment, 1915,	–	–	–	–	–	–	–	$7,737 96	–	–	7,737 96
Farm,	–	–	–	–	–	–	–	31,441 99	–	–	31,441 99
General horticulture,	–	–	–	–	–	–	–	7,234 72	–	–	7,234 72
Graduate school,	–	–	–	–	–	–	–	82 26	–	–	82 26
Grounds,	–	–	–	–	–	–	–	3,616 53	–	–	3,616 53
Library,	–	–	–	–	–	–	–	6,804 27	–	–	6,804 27
Operating and maintenance,	–	–	–	–	–	–	–	56,541 14	–	–	56,541 14
Improvements, 1915,	–	–	–	–	–	–	–	7,455 01	–	–	7,455 01
Totals,	$2,944 75	$16,870 49	$33,034 83	$871 23	$2,002 63	$957 62	$1,066 41	$121,654 99	$311 99	–	$179,714 94
Instruction (salaries),	–	–	–	–	–	–	–	–	–	$131,563 67	$131,563 67
Grand total,	–	–	–	–	–	–	–	–	–	–	$342,659 93

CURRENT ACCOUNTS.

Disbursements and Receipts.

ACCOUNTS.	Disbursements from Nov. 30, 1914, to Nov. 30, 1915.	Receipts from Nov. 30, 1914, to Nov. 30, 1915.	Apportionment for Year ending Nov. 30, 1915.	Balance to Credit.
Administration: —				
Dean's office,	$486 04	-	$500 00	$13 96
Executive order,	7,915 34	$48 85	5,800 00	—2,066 49
President's office,	937 99	55	900 00	—37 44
Registrar's office,	514 28	-	500 00	—14 28
Salaries,	20,108 21	-	20,100 00	—8 21
Treasurer's office,	1,419 46	-	1,200 00	—219 46
State Treasurer,	-	31,000 00	-	-
Maintenance, academic: —				
Agricultural economics,	164 45	17 25	175 00	27 80
Agricultural education,	508 11	96	500 00	—7 15
Agronomy,	445 80	511 00	150 00	215 20
Animal husbandry,	543 75	280 00	300 00	36 25
Beekeeping,	1,597 29	103 79	1,500 00	6 50
Botany,	1,386 06	674 48	750 00	38 42
Chemistry,	4,661 05	2,961 28	2,000 00	300 23
Dairying,	21,917 41	18,696 58	3,600 00	379 17
Economics and sociology,	36 40	-	50 00	13 60
Entomology,	732 70	114 06	775 00	156 36
Farm administration,	585 11	28 38	650 00	93 27
Floriculture,	4,669 08	3,087 20	1,100 00	—481 88
Forestry,	327 72	167 40	400 00	239 68
History and government,	5 27	-	-	—5 27
Hospital,	741 11	30 77	1,100 00	389 66
Landscape gardening,	446 35	416 04	-	—30 31
Language and literature,	169 80	40	350 00	180 60
Market gardening,	3,644 91	1,487 65	2,000 00	—157 26
Mathematics,	263 66	90 00	225 00	51 34
Microbiology,	691 26	450 16	250 00	8 90
Military science,	1,310 48	5 90	1,300 00	— 58
Physical education,	922 69	1 25	600 00	—321 44
Physics,	586 38	93	500 00	—85 45
Pomology,	3,472 54	1,805 72	1,700 00	33 18
Poultry husbandry,	6,405 28	3,570 90	2,500 00	—334 38
Rural engineering,	461 98	106 56	350 00	—5 42
Rural sociology,	94 00	1 40	50 00	—42 60
Veterinary science,	1,235 66	27 13	1,000 00	—208 53
Zoölogy and geology,	774 76	414 75	325 00	—35 01
Maintenance, general: —				
Equipment, 1915,	7,737 96	-	10,000 00	2,262 04
Farm,	31,441 99	31,985 41	-	543 42
General horticulture,	7,234 72	3,819 30	2,800 00	—615 42
Graduate school,	82 26	-	100 00	17 74
Grounds,	3,616 53	507 70	3,500 00	391 17
Improvements, 1915,	7,455 01	10,000 00	10,000 00	2,544 99
Library,	6,804 27	607 71	6,500 00	303 44
Operating and maintenance,	56,541 14	13,603 71	52,000 00	11,734 91
State Treasurer, maintenance,	-	90,000 00	-	-
Land,	-	5,000 00	-	-
Endowment fund,	-	10,613 32	-	-
Instruction: —				
Salaries,	131,563 67	373 34	-	-
United States Treasurer: —				
Morrill fund,	-	16,666 66	-	-
Nelson fund,	-	16,666 67	-	-
State Treasurer: —				
Instruction,	-	90,000 00	-	-
Graduate school,	-	2,000 00	-	-
Totals,	$342,659 93	$357,945 16	-	-
Balance beginning fiscal year Dec. 1, 1914,	-	16,072 43	-	-
Balance on hand Nov. 30, 1915,	31,357 66	-	-	-
	$374,017 59	$374,017 59	-	-

COLLEGE ACCOUNTS.

Comparative Disbursements and Receipts for 1914–15.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1914.	**1915.**	**1914.**	**1915.**
Agricultural economics,	$103 16	$164 45	–	$17 25
Agricultural education,	386 65	508 11	$58 00	96
Agronomy,	294 91	445 80	177 70	511 00
Animal husbandry,	593 44	543 75	176 50	280 00
Beekeeping,	1,676 10	1,597 29	8 15	103 79
Botany,	1,461 43	1,386 06	621 45	674 48
Chemistry,	4,499 79	4,661 05	2,655 14	2,961 28
Dairying,	16,549 52	21,917 41	13,296 38	18,696 58
Dean's office,	511 24	486 04	–	–
Economics and sociology,	32 65	36 40	–	–
Entomology,	664 03	732 70	125 47	114 06
Equipment,	11,271 71	7,737 96	115 00	–
Executive order,	6,196 47	7,915 34	2 50	48 85
Farm administration,	377 12	585 11	2 94	28 38
Farm,	28,869 16	31,441 99	21,211 36	31,985 41
Floriculture,	4,005 47	4,669 08	2,991 24	3,087 20
Forestry,	402 60	327 72	65 10	167 40
General horticulture,	4,316 98	7,234 72	1,681 26	3,819 30
Graduate school,	90 99	82 26	–	–
Grounds,	3,026 66	3,616 53	30 16	507 70
History and government,	10 61	5 27	–	–
Hospital,	–	741 11	–	30 77
Improvements,	8,508 96	7,455 01	64 44	–
Landscape gardening,	394 56	446 35	397 67	416 04
Language and literature,	286 59	169 80	–	40
Library,	6,761 82	6,804 27	570 73	607 71
Market gardening,	3,763 96	3,644 91	1,604 54	1,487 65
Mathematics,	172 83	263 66	–	90 00
Military,	1,326 46	1,310 48	–	5 90
Microbiology,	901 10	691 26	301 10	450 16
Physical education,	715 90	922 69	123 50	1 25
Physics,	645 52	586 38	–	93
Pomology,	3,847 29	3,472 54	1,464 67	1,805 72
Poultry husbandry,	5,080 67	6,405 28	3,215 00	3,570 90
President's office,	872 49	937 99	50	55
Registrar's office,	439 25	514 28	–	–
Rural engineering,	96 33	461 98	–	106 56
Rural sociology,	40 76	94 00	–	1 40
Salaries,	144,894 92	151,671 88	236 81	373 34
Treasurer's office,	1,253 40	1,419 46	17	–
Veterinary,	996 53	1,235 66	14 82	27 13
Zoölogy and geology,	772 70	774 76	351 17	414 75
Operating and maintenance,	49,640 03	56,541 14	10,936 02	13,603 71
State Treasurer: —				
Endowment fund,	–	–	10,613 32	10,613 32
Graduate school,	–	–	2,000 00	2,000 00
Maintenance,	–	–	93,000 00	105,000 00
Instruction,	–	–	85,000 00	90,000 00
Administration,	–	–	30,000 00	31,000 00
United States Treasurer: —				
Morrill fund,	–	–	16,666 66	16,666 66
Nelson fund,	–	–	16,666 67	16,666 67
Totals,	$316,752 76	$342,659 93	$316,446 14	$357,945 16
Balance beginning fiscal year,	–	–	16,379 05	16,072 43
Balance on hand at close of fiscal year,	16,072 43	31,357 66	–	–
	$332,825 19	$374,017 59	$332,825 19	$374,017 59

COLLEGE ACCOUNTS — *Concluded.*

Summary.

	Disbursements.	Credits.
Cash on hand Dec. 1, 1914,	–	$16,072 43
Institution receipts Nov. 30, 1915,	–	85,998 51
State Treasurer receipts Nov. 30, 1915,	–	238,613 32
United States Treasurer's receipts Nov. 30, 1915,	–	33,333 33
Total disbursements,	$342,659 93	–
	$342,659 93	$374,017 59
Bills receivable Dec. 1, 1914, deducted,	–	6,855 03
Bills payable Dec. 1, 1914, deducted,	2,893 65	–
	$339,766 28	$367,162 56
Bills receivable Nov. 30, 1915,	–	5,669 36
Bills payable Nov. 30, 1915,	2,742 27	–
Balance,	30,323 37	–
	$372,831 92	$372,831 92

COLLEGE EQUIPMENT, 1915.

	Disbursements Fiscal Year.		Disbursements Fiscal Year.
Dairy,	$1,767 60	Floriculture,	$190 75
Physics,	407 46	Hospital,	760 05
Horticulture,	88 00	Agricultural economics,	62 90
Market gardening,	75 75	Pomology,	368 73
Library,	155 01	Language and literature,	198 18
Microbiology,	498 30	Operating and maintenance,	75 00
Chemistry,	397 95	Mathematics,	50 00
Farm,	575 02	Registrar's office,	25 00
Zoölogy,	232 20	Agronomy,	27 35
Veterinary,	338 05	Landscape gardening,	299 40
Poultry,	829 54	Rural sociology,	97 18
Botany,	153 85		
Forestry,	49 50	Total,	$7,737 96
Beekeeping,	15 19		

FARM DISBURSEMENTS.

	Labor.	Equipment.	Feed.	Fertilizer.	Seeds.	Miscellaneous.	Supplies.	Improvements.	Totals.
Cattle,	$5,759 19	–	$2,669 21	–	–	–	$726 37	–	$9,154 77
Dairy,	1,833 88	$21 09	–	–	–	–	2,248 39	–	4,103 36
Horses,	1,607 80	–	480 00	–	–	–	1,079 94	–	3,167 74
Sheep,	225 25	–	–	–	–	–	11 10	–	236 35
Swine,	401 92	–	577 51	–	–	–	64 79	–	1,044 22
Field crops,	3,864 62	–	–	$857 67	$232 97	–	58 70	–	5,013 96
Miscellaneous,	2,082 52	–	–	–	–	–	99 38	$1,344 58	3,526 48
Tools and machinery,	–	485 19	–	–	–	–	–	–	485 19
Live stock,	–	–	–	–	–	–	–	–	–
Supplies,	–	–	–	–	–	–	4,709 92	–	4,709 92
Totals,	$15,775 18	$506 28	$3,726 72	$857 67	$232 97	–	$8,998 59	$1,344 58	$31,441 99

FARM CREDITS.

	Milk.	Stock.	Sundry.	Hay.	Roots.	Labor.	Potatoes.	Totals.
Cattle,	$13,737 90	–	$283 97	–	–	–	–	$14,021 87
Dairy,	13,086 68	–	1 70	–	–	–	–	13,088 38
Horses,	–	$640 00	884 21	–	–	–	–	1,524 21
Sheep,	–	55 00	54 14	–	–	–	–	109 14
Swine,	–	344 63	7 50	–	–	–	–	352 13
Field crops,	–	–	50	$927 07	$33 84	–	$739 23	1,700 64
Miscellaneous,	–	–	181 14	–	–	$1,007 90	–	1,189 04
Totals,	$26,824 58	$1,039 63	$1,413 16	$927 07	$33 84	$1,007 90	$739 23	$31,985 41

AGRICULTURAL DIVISION.

Disbursements and Receipts.

	Disbursements.	Receipts.
Agronomy,	$445 80	$511 00
Animal husbandry,	543 75	280 00
Dairying,	21,917 41	18,696 58
Farm,	31,441 99	31,985 41
Farm administration,	585 11	28 38
Poultry husbandry,	6,405 28	3,570 90
Rural engineering,	461 98	106 56
Division totals,	$61,801 32	$55,178 83

Summary.

	Dr.	Cr.
By total division receipts,		$55,178 83
By bills receivable,		3,748 14
By net apportionment,		7,200 00
To total disbursements,	$61,801 32	
To bills payable,	1,383 16	
Balance,	2,942 49	
	$66,126 97	$66,126 97

Inventory of Quick Assets.

	Nov. 30, 1914.	Nov. 30, 1915.
Inventory of produce,	$8,938 35	$11,518 42
Inventory of cattle,	13,645 00	14,945 00
Inventory of swine,	375 00	900 00
Inventory of horses,	5,450 00	5,425 00
Inventory of poultry,	941 25	1,162 25
Inventory of sheep,	647 00	591 00
	$29,996 60	$34,541 67

HORTICULTURAL DIVISION.

Disbursements and Receipts.

	Disbursements.	Receipts.
Floriculture,	$4,669 08	$3,087 20
Forestry,	327 72	167 40
General horticulture,	7,234 72	3,819 30
Grounds,	3,616 53	507 70
Landscape gardening,	446 35	416 04
Market gardening,	3,644 91	1,487 65
Pomology,	3,472 54	1,805 72
Division totals,	$23,411 85	$11,291 01

HORTICULTURAL DIVISION — *Concluded.*

Summary.

	DR.	CR.
By total division receipts,		$11,291 01
By bills receivable,		1,094 09
By apportionment,		11,500 00
To total division disbursements,	$23,411 85	
To bills payable,	788 88	
By balance,		315 63
	$24,200 73	$24,200 73

Inventory of Quick Assets.

	Nov. 30, 1914.	Nov. 30, 1915.
Floriculture,	$523 50	$550 00
Market gardening,	107 50	121 50
Pomology,	612 50	375 00
General horticulture (live stock),	1,625 00	1,695 00
	$2,868 50	$2,741 50

EXPENSE OPERATING AND MAINTENANCE.

	Salaries.	Labor.	Fuel and Water.	Repairs.	Supplies.	Tools.	Architect.	Engineer.	Miscellaneous.	Totals.
General: —										
General superintendent,	$2,841 83	–	–	–	–	–	–	–	–	$2,841 83
Office,	–	$887 80	–	–	–	–	–	–	–	887 80
General expenses,	–	–	–	–	$2,672 34	–	–	–	–	2,672 34
Power plant: —										
Heat,	–	4,414 38	$22,771 62	$855 40	16 50	–	–	–	–	28,057 90
Light,	–	347 01	–	893 27	105 93	–	–	–	–	1,346 21
Tools,	–	–	–	–	–	$409 89	–	–	–	409 89
Waiting station janitor,	–	5 80	–	–	–	–	–	–	–	5 80
Amherst Water Company,	–	–	2,027 10	–	–	–	–	–	–	2,027 10
Night watchman,	–	1,318 32	–	–	–	–	–	–	–	1,318 32
Mail service,	–	325 84	–	–	–	–	–	–	–	325 84
Water mains,	–	748 51	–	–	–	–	–	–	–	748 51
Steam mains,	–	155 09	–	–	–	–	–	–	–	155 09
Sewers and cesspools,	–	22 34	–	–	–	–	–	–	–	22 34
Amherst Gas Company,	–	–	81 43	–	–	–	–	–	–	81 43
Electric light circuit,	–	240 16	–	–	–	–	–	–	–	240 16
Expert service,	–	–	–	–	–	–	$1,403 63	$50 00	–	1,453 63
Walks,	–	21 98	–	–	–	–	–	–	–	21 98
Emergency maintenance,	–	1,326 37	–	–	–	–	–	–	–	1,326 37
Drains,	–	6 25	–	–	–	–	–	–	–	6 25
Fire department,	1,034 28	16 35	–	–	112 08	–	–	–	$4 36	1,167 07
Sundry,	–	–	–	–	–	–	–	–	2,594 27	2,594 27
Totals,	$3,876 11	$9,836 20	$24,880 15	$1,748 67	$2,906 85	$409 89	$1,403 63	$50 00	$2,598 63	$47,710 13

EXPENSE OPERATING AND MAINTENANCE — *Continued.*

COLLEGE BUILDINGS.	Electric Repairs.	Plumbing Repairs.	Heat Repairs.	C. and M. Repairs.	Janitor.	Bell Ringing.	Sundry.	Totals.
College buildings: —								
Animal husbandry building,	–	$13 74	$4 34	$7 42	–	–	–	$25 50
Horse barn,	$0 77	4 31	6 79	13 84	–	–	–	25 71
Dairy barn,	6 43	33 10	7 10	33 43	–	–	–	80 06
Young stock barn,	97	9 29	75	60 78	–	–	–	71 79
Power building,	–	23 35	–	214 80	$151 59	–	–	389 74
Chemical building,	53	34 83	21 56	78 98	–	–	–	135 90
Poultry building,	1 83	8 10	–	22 74	–	–	–	32 67
Dairy building,	21 29	55 22	32 09	423 42	–	–	–	532 02
Drill hall,	2 19	23 93	5 31	79 52	–	–	–	110 95
Veterinary building,	–	4 41	19 44	73 54	–	–	–	97 39
Apiary building,	5 02	1 61	1 49	93 96	–	–	–	102 08
Mathematic building,	26	7 49	7 37	36 02	–	–	–	51 14
Entomology building,	4 47	21 09	11 48	262 56	–	–	–	299 60
Clark hall,	5 86	52 77	2 78	46 58	–	–	–	107 99
French hall,	23 29	9 00	45 04	434 70	–	–	–	512 03
Wilder hall,	16 08	15 63	1 51	29 07	–	–	–	62 29
Upper plant house,	–	59 03	11 62	57 66	–	–	–	128 31
Old Durfee range,	–	8 36	6 31	33 83	–	–	–	48 50
Horticulture barn,	31	46 30	6 65	19 57	–	–	–	72 83
Physics building,	–	20 24	4 00	44 39	–	–	–	68 63
East experiment station,	1 16	56 38	47 39	357 58	–	–	–	462 51
West experiment station,	3 71	31 77	12 16	64 49	–	–	–	112 13
Experiment station barn,	–	1 71	11 90	18 66	–	–	–	32 27
P. and A. chemistry barn,	28	26 53	3 19	89 28	–	–	–	119 28
Microbiology building,	24	–	61	–	–	–	$660 00	660 85
Draper hall,	48 14	260 02	53 17	142 54	–	–	168 25	672 12
Sheep barn,	–	–	–	7 31	–	–	–	7 31
Piggery,	–	7 66	–	2 81	–	–	–	10 47
Cold-storage building,	–	11 72	–	79 37	–	–	–	91 09
Machine barn,	–	1 82	–	3 25	–	–	–	5 07
Hospital,	3 37	54	3 97	43 95	–	–	73 54	125 37
Rural engineering building,	–	41	–	–	–	–	–	41
Stockbridge hall,	–	–	1 34	42	–	–	–	1 76
North College,	59 27	32 65	17 07	195 45	577 32	–	135 40	1,017 16
South College,	57 09	67 25	22 00	403 28	559 13	–	136 85	1,245 60
Chapel,	36 01	6 37	45	56 84	240 40	$120 00	10 00	470 07

College residences: —								
Harlow place,	–	5 52	–	1 50	–	–	–	7 02
Kellogg place,	–	3 13	–	14 75	–	–	9 12	27 00
President's house,	7 17	24 06	8 02	138 56	–	–	63 40	241 21
Farm superintendent's house,	57	15 71	1 86	38 93	–	–	–	57 07
Farm helps' house,	–	20 99	4 59	49 80	–	–	–	75 38
Stockbridge house,	–	2 15	–	1 47	–	–	–	3 62
Waugh house,	13 91	223 57	5 07	174 51	–	–	–	417 06
Farm cottage,	–	3 42	4 81	1 40	–	–	–	9 63
Registrar's house,	–	–	4 42	–	–	–	–	4 42
Totals,	$320 22	$1,255 18	$397 65	$3,952 96	$1,528 44	$120 00	$1,256 56	$8,831 01

Summary.

General,	$47,710 13
College buildings,	7,988 60
College residences,	842 41
	$56,541 14

Experiment Station.

Disbursements and Receipts.

Accounts.	Disbursements from Dec. 1, 1914, to Nov. 30, 1915.	Receipts from Dec. 1, 1914, to Nov. 30, 1915.	Apportionment for Year ending Nov. 30, 1915.	Balance to Credit.
Administration,	$1,011 28	$34 72	$1,400 00	$423 44
Agriculture,	5,247 13	2,365 01	2,575 00	—307 12
Asparagus,	701 48	–	500 00	—201 48
Botanical,	1,469 01	3 00	1,500 00	33 99
Chemical,	11,015 52	10,732 09	1,000 00	716 57
Cranberry,	3,015 05	2,437 01	3,000 00	2,421 96
Entomology,	477 98	–	600 00	122 02
Feed inspection,	5,337 54	6,000 00	–	–
Fertilizer inspection,	10,047 01	10,088 00	–	–
Freight and expense,	311 55	32	400 00	88 77
Graves orchard,	737 73	1,027 19	800 00	1,089 46
Horticultural,	1,803 75	187 64	1,600 00	—16 11
Library,	855 91	–	700 00	—155 91
Meteorology,	278 49	–	375 00	96 51
Poultry,	2,034 82	4 33	1,700 00	—330 49
Publication,	818 66	–	800 00	—18 66
Salaries,	39,199 74	–	38,481 65	—718 09
Treasurer's office,	377 87	–	375 00	—2 87
Veterinary,	238 11	–	1,925 00	1,686 89
Agricultural economics,	605 94	–	1,000 00	394 06
Microbiology,	773 08	–	800 00	26 92
Equipment,	1,821 22	–	2,000 00	178 78
Miscellaneous,	–	90 00	–	–
Hatch fund,	–	15,000 00	–	–
Adams fund,	–	15,000 00	–	–
State fund,	–	25,000 00	–	–
Totals,	$88,178 87	$87,969 31	$61,531 65	$5,528 64
Balance on hand beginning fiscal year, Dec. 1, 1914,	–	8,286 85	–	–
Balance on hand Nov. 30, 1915,	8,077 29	–	–	–
	$96,256 16	$96,256 16	–	–

EXPERIMENT STATION — *Continued.*

Comparative Disbursements and Receipts, 1914–15.

ACCOUNTS.	DISBURSEMENTS.		RECEIPTS.	
	1914.	**1915.**	**1914.**	**1915.**
Administration,	$1,416 13	$1,011 28	$4 92	$34 72
Agriculture,	5,058 48	5,247 13	2,494 49	2,365 01
Asparagus,	757 60	701 48	–	–
Botanical,	1,895 80	1,469 01	50 00	3 00
Chemical,	10,252 46	11,015 52	10,013 33	10,732 09
Cranberry,	2,886 76	3,015 05	2,676 86	2,437 01
Entomology,	556 56	477 98	4 50	–
Feed inspection,	5,897 93	5,337 54	6,018 67	6,000 00
Fertilizer inspection,	9,744 92	10,047 01	11,112 00	10,088 00
Freight and express,	532 56	311 55	24 55	32
Graves orchard,	789 08	737 73	129 25	1,027 19
Horticultural,	1,936 83	1,803 75	11 46	187 64
Library,	248 75	855 91	–	–
Meteorology,	374 24	278 49	–	–
Poultry,	1,066 63	2,034 82	4 17	4 33
Publications,	912 47	818 66	–	–
Salaries,	36,202 83	39,199 74	18 67	–
Treasurer's office,	364 44	377 87	–	–
Veterinary,	597 15	238 11	–	–
Equipment,	–	1,821 22	–	–
Agricultural economics,	–	605 94	–	–
Microbiology,	–	773 08	–	–
Miscellaneous,	96 30	–	160 00	90 00
Hatch fund,	–	–	15,000 00	15,000 00
Adams fund,	–	–	15,000 00	15,000 00
State fund,	–	–	20,000 00	25,000 00
Totals,	$81,587 92	$88,178 87	$82,722 87	$87,969 31
Balance beginning fiscal year,	–	–	7,151 90	8,286 85
Balance on hand at close of fiscal year,	8,286 85	8,077 29	–	–
	$89,874 77	$96,256 16	$89,874 77	$96,256 16

Analysis of Experiment Station Accounts.

	Adams Fund.	Fertilizer Law.	Feed Law.	Hatch Fund.	State Fund.	Totals.
Salaries,	$14,527 47	$6,617 92	$3,880 42	$12,674 25	$11,998 02	$49,698 08
Labor,	–	950 35	125 83	1,020 54	16,199 24	18,295 96
Publication,	–	706 58	520 38	–	368 55	1,595 51
Postage and stationery,	–	179 92	61 29	–	1,760 31	2,001 52
Freight and express,	–	35 91	4 05	–	391 26	431 22
Heat, light, water and power,	–	92 63	35 25	26 79	294 85	449 52
Chemistry and laboratory supplies,	–	438 16	181 23	682 52	1,488 78	2,790 69
Seeds, plants and sundry supplies,	–	44 85	20 16	392 09	2,142 64	2,599 74
Fertilizers,	–	46 71	–	46 25	323 40	416 36
Feeding stuffs,	–	–	–	7 20	900 69	907 89
Library,	–	11 50	5 00	16 92	942 57	975 99
Tools, machinery and appliances,	–	172 65	4 50	6 06	419 86	603 07
Furniture and fixtures,	–	62 10	16 86	–	469 51	548 47
Scientific apparatus and specimens,	–	79 56	9 09	16 88	935 00	1,040 53
Live stock,	–	–	–	–	77 66	77 66
Traveling expenses,	–	573 56	447 85	38 22	1,885 18	2,944 81
Contingent expenses,	–	–	5 00	–	109 50	114 50
Buildings and land,	–	34 61	20 63	–	1,454 55	1,509 79
Miscellaneous,	–	–	–	–	24 62	24 62
Equipment,	–	–	–	–	1,152 94	1,152 94
Totals,	$14,527 47	$10,047 01	$5,337 54	$14,927 72	$43,339 13	$88,178 87

EXPERIMENT STATION — *Concluded.*

Summary.

	Disbursements.	Receipts.
Cash on hand Dec. 1, 1914,	–	$8,286 85
Receipts from State Treasurer,	–	31,000 00
Receipts from United States Treasurer,	–	30,000 00
Receipts from other sources,	–	26,969 31
Total disbursements,	$88,178 87	–
	$88,178 87	$96,256 16
Bills receivable Nov. 30, 1915,	–	865 22
Bills payable Nov. 30, 1915,	862 39	–
Balance,	8,080 12	–
	$97,121 38	$97,121 38

EXTENSION SERVICE.

Disbursements and Receipts.

ACCOUNTS.	Disbursements.	Receipts.	Apportionment.	Balance.
Administration,	$2,015 04	$62 92	$3,050 00	$1,097 88
Agricultural education,	2,132 94	3 23	2,250 00	120 29
Agricultural economics,	480 10	31 30	400 00	—48 80
Animal husbandry,	460 32	112 98	350 00	2 66
Auto demonstration outfit,	62 99	34 88	300 00	271 89
Apple packing school,	105 29	105 00	100 00	99 71
Assistant State leader,	640 62	–	760 00	119 38
Beekeeping,	80 22	–	200 00	119 78
Boys' camp,	974 77	837 45	200 00	62 68
Civic improvement,	814 12	410 45	500 00	96 33
Community service,	610 59	16 51	550 00	—44 08
Conference rural social workers,	503 43	–	500 00	—3 43
Correspondence courses,	1,035 95	655 67	200 00	—180 28
County agents,	279 95	–	200 00	—79 95
Dairying,	109 23	–	100 00	—9 23
Director's office,	1,193 18	29 05	1,300 00	135 87
Equipment,	1,413 80	–	2,100 00	686 20
Farm management,	439 13	262 03	100 00	—77 10
Farmers' week,	435 35	–	1,000 00	564 65
Home economics,	293 19	–	350 00	56 81
Hog cholera,	–	–	100 00	100 00
Itinerant instruction,	2,562 42	840 88	1,600 00	—121 54
Library extension,	44 46	1 80	200 00	157 34
M. A. C. Improvement Association,	–	–	100 00	100 00
Market gardening,	330 87	27 20	225 00	—78 67
Miscellaneous,	–	–	100 00	100 00
Pomology,	620 17	–	550 00	—70 17
Poultry convention,	310 69	–	300 00	—10 69
Poultry husbandry,	100 93	–	150 00	49 07
Salaries,	29,375 45	696 69	27,860 26	—818 50
Summer school,	4,111 05	910 56	2,500 00	—700 49
Ten weeks' school,	1,822 68	990 50	1,300 00	467 82
Tree warden school,	11 80	–	100 00	88 20
From State Treasurer,	–	50,000 00	–	–
Unapportioned balance,	–	–	–	9,456 11
Totals,	$53,370 73	$56,029 10	$49,595 26	$11,709 74
Balance beginning fiscal year Dec. 1, 1914,	–	9,051 37	–	–
Balance on hand Nov. 30, 1915,	11,709 74	–	–	–
	$65,080 47	$65,080 47	–	–

EXTENSION SERVICE — *Continued.*

Summary.

	Disbursements.	Receipts.
Balance Dec. 1, 1914,	–	$10,486 86
Receipts Nov. 30, 1915,	–	6,029 10
Received from State Treasurer,	–	50,000 00
Received from United States Treasurer,	–	11,465 37
Disbursements to Nov. 30, 1915,	$64,486 07	–
	$64,486 07	$77,981 33
Bills receivable Dec. 1, 1914, deducted,	–	899 26
Bills payable Dec. 1, 1914, deducted,	468 87	–
	$64,017 20	$77,082 07
Bills receivable Nov. 30, 1915,	–	152 00
Bills payable Nov. 30, 1915,	594 31	–
Balance,	12,622 56	–
	$77,234 07	$77,234 07

EXTENSION SERVICE — *Concluded.*

Analysis of Extension Service Disbursements.

	Travel.	Equipment.	Laboratory Expense.	Printing.	Supplies.	Instruction and Lectures.	Salaries.	Miscellaneous.	Totals.
Administration,	$1,209 07	$12 64	-	$562 15	$201 05	-	$29,375 45	$42 77	$31,403 13
Agricultural education,	743 12	239 82	-	-	162 35	-	-	1,227 47	2,372 76
Agricultural economics,	447 39	32 02	-	-	32 71	-	-	-	512 12
Animal husbandry,	197 05	32 97	-	-	263 27	-	-	-	493 29
Auto demonstration outfit,	61 70	35 00	-	-	-	-	-	1 29	97 99
Apple packing school,	22 50	72 79	-	-	-	-	-	10 00	105 29
Assistant State leader,	600 79	1 31	-	-	39 83	-	-	-	641 93
Beekeeping,	58 22	22 00	-	-	-	-	-	-	80 22
Boys' camp,	33 98	932 79	-	-	-	-	-	8 00	974 77
Civic improvement,	179 81	142 63	-	-	634 31	-	-	-	956 75
Community service,	554 85	30 34	-	-	55 74	-	-	-	640 93
Conference rural social workers,	234 69	-	-	-	-	-	-	268 74	503 43
Correspondence courses,	136 07	114 70	-	-	634 05	-	-	265 83	1,150 65
County agents,	279 95	5 50	-	-	-	-	-	-	285 45
Dairying,	101 73	67 63	-	-	7 50	-	-	-	176 86
Director's office,	-	243 80	-	-	1,016 23	-	-	176 95	1,436 98
Farm management,	242 78	129 19	-	-	196 35	-	-	-	568 32
Farmers' week,	17 16	-	-	-	418 19	-	-	-	435 35
Home economics,	197 19	110 55	-	-	96 00	-	-	-	403 74
Itinerant instruction,	381 12	48 92	-	-	577 55	-	-	1,603 75	2,611 34
Library extension,	-	106 32	-	-	-	-	-	44 46	150 78
Market gardening,	307 30	-	-	-	23 57	-	-	-	330 87
M. A. C. Improvement Association,	-	9 00	-	-	-	-	-	-	9 00
Pomology,	429 49	22 71	-	-	190 68	-	-	-	642 88
Poultry convention,	62 92	-	-	-	247 77	-	-	-	310 69
Poultry husbandry,	99 83	28 75	-	-	1 10	-	-	-	129 68
Summer School,	113 36	-	$146 48	-	125 58	$2,783 24	-	501 48	3,670 14
Ten weeks' school,	17 36	-	-	200 39	-	658 25	-	946 68	1,822 68
Tree warden's school,	11 80	-	-	440 91	-	-	-	-	452 71
Totals,	$6,741 23	$2,441 38	$146 48	$1,203 45	$4,923 83	$3,441 49	$29,375 45	$5,097 42	$53,370 73

SMITH-LEVER FUND (FEDERAL).

	Disbursements.	Receipts.	Apportionment.	Balance.
Animal husbandry,	$355 88	–	$200 00	—$155 88
Boys' and girls' club,	1,017 51	–	1,000 00	—17 51
Contingent,	34 60	–	145 35	110 75
Dairying,	154 62	–	200 00	45 38
Demonstration auto truck,	60 27	–	350 00	289 73
Farm management,	692 74	–	760 00	67 26
Home economics,	754 10	–	687 50	—66 60
Market gardening,	114 11	–	–	—114 11
Pomology,	218 82	–	200 00	—18 82
Poultry,	244 91	–	250 00	5 09
Publication,	627 26	–	500 00	—127 26
Salaries,	6,840 52	–	5,886 63	—953 89
County agents,	–	–	750 00	750 00
Extension schools,	–	–	291 67	291 67
From State Treasurer,	–	$11,465 37	–	–
Totals,	$11,115 34	$11,465 37	$11,221 15	$105 81
Balance beginning fiscal year Dec. 1, 1914,	–	1,644 35	–	–
Balance on hand Nov. 30, 1915,	1,994 38	–	–	–
	$13,109 72	$13,109 72	–	–

SPECIAL APPROPRIATIONS.

	Date made.	Amount of Apportionment.	Amount previously expended.	Amount expended during Fiscal Year.	Amount expended to Date.	Amount received from State Treasurer.	Balance on Hand with State Treasurer.
Hospital,	1913	$15,000 00	$1,947 52	$13,052 48	$15,000 00	$15,000 00	–
Sewers,[1]	1914	9,200 00	–	9,200 00	9,200 00	9,200 00	–
Agricultural building,	1914	210,000 00	16,194 75	176,629 92	192,824 67	192,824 67	$17,175 33
Addition to power plant,	1915	10,000 00	–	10,000 00	10,000 00	10,000 00	–
Microbiology building,	1915	67,500 00	–	14,754 27	14,754 27	14,754 27	52,745 73
Totals,	. .	$311,700 00	$18,142 27	$223,636 67	$241,778 94	$241,778 94	$69,921 06

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[1] In conjunction with town of Amherst for the Connecticut River outlet.

Inventory — Real Estate.

Land (Estimated Value).

Baker place,	$2,500 00
Bangs place,	2,350 00
Clark place,	4,500 00
College farm,	37,000 00
Cranberry land,	10,997 50
Harlow farm,	3,284 63
Kellogg farm,	5,868 45
Louisa Baker place,	5,000 00
Old creamery place,	1,000 00
Pelham quarry,	500 00
Westcott place,	2,250 00
Allen place,	500 00
Charmbury place,	450 00
Loomis place,	415 00
Hawley & Brown place,	675 00
Newell farm,	2,800 00
Owen farm,	5,000 00
Total,	$85,090 58

College Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Value at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value.
Apiary,	$3,000 00	2	$2,940 00	$102 08	$3,042 08
Animal husbandry building,	10,000 00	2	9,800 00	25 50	9,825 50
Chemical laboratory,	8,000 00	5	7,600 00	135 90	7,735 90
Clark hall,	67,500 00	2	66,150 00	309 04	66,459 04
Cold-storage laboratory,	12,000 00	2	11,760 00	91 09	11,851 09
Dairy building,	75,000 00	2	73,500 00	724 17	74,224 17
Dairy barn and storage,	30,000 00	3	29,100 00	80 06	29,180 06
Dining hall,	60,000 00	3	58,200 00	503 87	58,703 87
Drill hall and gun shed,	10,000 00	5	9,500 00	140 28	9,640 28
Durfee glass houses, old,	10,000 00	5	9,500 00	48 50	9,548 50
Durfee glass houses, new,	15,000 00	5	14,250 00	326 72	14,576 72
Entomology building,	80,000 00	2	78,400 00	373 17	78,773 17
Farm bungalow,	2,100 00	3	2,037 00	9 63	2,046 63
Farmhouse,	2,500 00	3	2,425 00	57 07	2,482 07
French hall,	50,000 00	2	49,000 00	710 76	49,710 76
Horse barn,	5,000 00	3	4,850 00	25 71	4,875 71
Horticultural barn,	2,500 00	3	2,425 00	72 83	2,497 83
Horticultural tool shed,	2,000 00	3	1,940 00	–	1,940 00
Hospital,	–	–	15,000 00	452 28	15,452 28
Machinery barn,	4,000 00	3	3,880 00	5 07	3,885 07
Mathematical building,	6,000 00	5	5,700 00	51 14	5,751 14
North dormitory,	25,000 00	2	24,500 00	304 44	24,804 44
Physics laboratory,	5,500 00	5	5,225 00	114 06	5,339 06
Piggery,	3,000 00	3	2,910 00	10 47	2,920 47
Poultry department: —					
Breeding houses,	1,600 00	2	1,568 00	–	1,568 00
Brooder house,	1,000 00	2	980 00	103 55	1,083 55
Incubator cellar and building,	1,400 00	2	1,372 00	–	1,372 00
Incubator cellar and storage building,	–	–	800 00	–	800 00
Crematory,	–	–	50 00	–	50 00

College Buildings (*Estimated Value*) — Concluded.

	Inventory at Beginning of Year.	Per Cent.	Value at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements during Year.	Total Value.
Poultry department — *concluded.*					
Duck house,	–	–	$100 00	–	$100 00
Laboratory,	$1,300 00	2	1,274 00	$71 51	1,345 51
Laying house,	1,800 00	2	1,764 00	–	1,764 00
Mechanics and storage building,	1,900 00	2	1,862 00	32 67	1,894 67
Power plant and storage building,	18,500 00	2	18,130 00	12,742 28	30,872 28
President's house,	12,000 00	3	11,640 00	241 21	11,881 21
Quarantine barn,	200 00	3	194 00	–	194 00
Rural engineering building,	–	–	3,550 00	–	3,550 00
Sheep barn,	1,400 00	3	1,358 00	57 66	1,415 66
South dormitory,	35,000 00	2	34,300 00	948 44	35,248 44
Stockbridge hall,	–	–	184,000 00	–	184,000 00
Agronomy greenhouse,	–	–	2,150 00	–	2,150 00
Stone chapel,	30,000 00	2	29,400 00	110 58	29,510 58
Three houses on Stockbridge road,	5,000 00	5	4,750 00	425 10	5,175 10
Vegetable plant house,	4,700 00	5	4,465 00	128 31	4,593 31
Veterinary laboratory and stable,	23,500 00	2	23,030 00	97 39	23,127 39
Waiting station,	500 00	2	490 00	5 80	495 80
Wilder hall,	37,500 00	2	36,750 00	62 29	36,812 29
Young stock barn,	6,500 00	3	6,305 00	114 50	6,419 50
Totals,	$671,900 00	–	$860,874 00	$19,815 13	$880,689 13

College Equipment (*Estimated Value*).

Administrative division: —	
Dean's office,	$502 11
President's office,	1,250 60
Registrar's office,	909 00
Treasurer's office,	2,458 41
Agricultural division: —	
Agronomy,	6,213 52
Animal husbandry,	857 48
Dairy,	13,612 92
Farm administration,	882 56
Farm department,	39,291 63
Poultry,	4,195 47
Rural engineering,	2,159 81
Dining hall,	6,279 37
Extension,	10,311 41
General science: —	
Apiary,	1,482 07
Botanical,	10,133 21
Chemical,	12,844 55
Entomology,	6,715 71
Microbiology,	5,805 00
Mathematics,	2,431 00
Physics,	4,463 02
Veterinary,	9,843 18
Zoölogical laboratory,	10,023 55
Zoölogical museum,	6,511 05
Graduate school,	70 76

Horticultural division: —		
Floriculture,		$8,559 12
Forestry,		2,598 63
General horticulture,		7,606 22
Grounds,		793 93
Landscape gardening,		5,113 78
Market gardening,		1,320 03
Pomology,		5,008 34
Hospital,		815 22
Humanities, division of: —		
Economics and sociology,		107 87
Language and literature,		396 73
Library,		83,700 85
Military,		1,485 42
Operating and maintenance: —		
College supply,		794 16
Fire apparatus,		1,859 15
General maintenance,		89,846 57
Equipment,	$78,326 85	
Carpentry and masonry supplies,	3,703 17	
Electrical supplies,	1,131 33	
Heating and plumbing supplies,	5,744 84	
Painting supplies,	940 38	
Janitors' supplies,		410 46
Sewer line,		12,103 00
Water mains,		10,924 81
Physical education,		2,737 98
Rural social science: —		
Agricultural economics,		385 50
Agricultural education,		835 59
Rural sociology,		240 33
Textbooks,		401 15
Trophy room,		1,647 10
Total,		$398,939 33

Experiment Station Buildings (Estimated Value).

	Inventory at Beginning of Year.	Per Cent.	Cost at Beginning of Year less Per Cent. Deterioration.	Repairs and Improvements.	Total Value.
Agricultural laboratory,	$15,000 00	2	$14,700 00	$462 51	$15,162 51
Agricultural barns,	5,000 00	3	4,850 00	32 27	4,882 27
Agricultural farmhouse,	1,500 00	3	1,455 00	–	1,455 00
Agricultural glass house,	500 00	5	475 00	–	475 00
Cranberry buildings,	2,800 00	–	2,645 00	–	2,645 00
Plant and animal chemistry laboratory,	30,000 00	2	29,400 00	112 13	29,512 13
Plant and animal chemistry barns,	4,000 00	3	3,880 00	119 28	3,999 28
Plant and animal chemistry dairy,	2,000 00	3	1,940 00	–	1,940 00
Six poultry houses,	600 00	2	588 00	–	588 00
Entomological glass houses,	825 00	5	783 75	–	783 75
Totals,	$62,225 00	–	$60,716 75	$726 19	$61,442 94

Experiment Station Equipment (Estimated Value).

Agricultural laboratory,	$6,815	61
Botanical laboratory,	6,450	65
Chemical laboratory,	17,504	59
Cranberry station,	2,863	64
Director's office,	4,584	34
Entomological laboratory,	24,134	42
Horticultural laboratory,	2,245	00
Meteorology laboratory,	928	00
Microbiology laboratory,	340	00
Poultry department,	3,807	16
Treasurer's office,	1,106	50
Veterinary laboratory,	65	00
Total,	$70,844	91

Inventory Summary.

Land,	$85,090	58
College buildings,	880,689	13
College equipment,	398,939	33
Experiment station buildings,	61,442	94
Experiment station equipment,	70,844	91
Total,	$1,497,006	89

Students' Trust Fund Account.

	Disbursements for Year ending Nov. 30, 1915.	Receipts for Year ending Nov. 30, 1915.	Balance on Hand.	Balance brought forward Dec. 1, 1914.
Athletics,	$9,357 65	$10,910 29	$2,341 91	$789 27
College signal,	1,510 48	1,278 20	8 73	241 01
Dining hall,	56,589 75	50,839 32	—6,115 80	—365 37
Keys,	79 25	56 00	45 00	68 25
Students' deposits,	12,150 88	17,571 47	7,141 47	1,720 88
Social union,	493 96	698 35	699 60	495 22
Textbooks,	4,762 73	4,967 07	936 39	732 05
Athletic field,	3,704 13	2,515 46	—1,197 16	—8 49
Uniforms,	3,352 35	3,635 80	3,308 69	3,025 24
1913 index,	14 84	7 42	–	7 42
1915 index,	438 73	429 95	–	8 78
1916 index,	1,526 93	1,532 62	5 76	07
Totals,	$93,981 68	$94,441 95	$7,174 59	$6,714 33
Balance on hand Dec. 1, 1914,	–	6,714 32	–	–
Balance on hand Nov. 30, 1915,	7,174 59	–	–	–
	$101,156 27	$101,156 27	–	–

Detailed Statement of Dining Hall.

		Liabilities.	Resources.
1914.			
Dec. 1.	Balance,	$343 49	–
1915.			
Nov. 30.	Total disbursements,	56,589 75	–
	Outstanding bills,	1,033 49	–
	Total collections,	–	$50,839 32
	Accounts outstanding,	–	1,571 54
	Inventory,	–	3,449 77
	Balance,	–	2,106 10
		$57,966 73	$57,966 73

Endowment Fund.[1]

	Principal.	Income.
United States grant (5 per cent.),	$219,000 00	$7,300 00
Commonwealth grant (3½ per cent.),	142,000 00	3,313 32
	–	$10,613 32

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[1] This fund is in the hands of the State Treasurer, and the Massachusetts Agricultural College receives two-thirds of the income from the same.

Burnham Emergency Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
Two bonds American Telephone and Telegraph Company 4s, at $910,	$1,820 00	$2,000 00	$80 00
Two bonds Western Electric Company 5s, at $1,000,	2,000 00	2,000 00	100 00
	$3,820 00	$4,000 00	$180 00
Unexpended balance, Dec. 1, 1914,	–	–	140 55
Cash on hand Nov. 30, 1915,	–	–	$320 55

Library Fund.

Five bonds New York Central & Hudson River Railroad Company 4s, at $930,	$4,650 00	$5,000 00	$200 00
Five bonds Lake Shore & Michigan Southern Railroad Company 4s, at $950,	4,750 00	5,000 00	200 00
Two shares New York Central & Hudson River Railroad Company stock, at $102,	204 00	200 00	10 00
Amherst Savings Bank, deposit,	167 77	167 77	7 09
	$9,771 77	$10,367 77	$417 09
Nov. 20, 1915, transferred to college library account,	–	–	417 09

Special Funds.

Endowed Labor Fund (the Gift of a Friend of the College).

Two bonds American Telephone and Telegraph Company 4s, at $910,	$1,820 00	$2,000 00	$80 00
Two bonds, Lake Shore & Michigan Southern Railroad Company 4s, at $950,	1,900 00	2,000 00	80 00
One bond New York Central Railroad debenture 4s,	930 00	1,000 00	40 00
Amherst Savings Bank Deposit,	143 39	143 39	6 07
One bond Metropolitan Street Railway of Kansas City 5s,	950 00	1,000 00	–
	$5,743 39	$6,143 39	$206 07
Unexpended balance Dec. 1, 1914,	–	–	1,024 90
	–	–	$1,230 97
Disbursements for fiscal year ending Nov. 30, 1915,	–	–	1,000 00
Cash on hand Nov. 30, 1915,	–	–	$230 97

Whiting Street Scholarship Fund.

One bond New York Central debenture 4s,	$930 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	271 64	271 64	11 51
	$1,201 64	$1,271 64	$51 51
Unexpended balance Dec. 1, 1914,	–	–	136 16
Cash on hand Nov. 30, 1915,	–	–	$187 67

SPECIAL FUNDS — *Continued.*

Hills Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
One bond American Telephone and Telegraph Company 4s, at	$910 00	$1,000 00	$40 00
One bond New York Central & Hudson River Railroad debenture 4s, at	930 00	1,000 00	40 00
One bond New York Central & Hudson River Railroad debenture 3½s, at	870 00	1,000 00	35 00
Two bonds Metropolitan Street Railway of Kansas City 5s, at $950,	1,900 00	2,000 00	–
Three bonds Pacific Telephone and Telegraph Company 5s, at $990,	2,970 00	3,000 00	150 00
One bond Western Electric Company 5s, at	1,000 00	1,000 00	50 00
Boston & Albany Railroad stocks, 3⅝ shares, at $187,	677 88	362 50	31 68
Amherst Savings Bank, deposit,	72 75	72 75	3 06
Electric Securities Company bonds, $1\frac{9}{50}$, at $1,000,	1,121 00	1,180 00	59 00
	$10,451 63	$10,615 25	$408 74
Unexpended balance Dec. 1, 1914,	–	–	1,025 88
	–	–	$1,434 62
Disbursements for fiscal year ending Nov. 30, 1915,	–	–	534 85
Cash on hand Nov. 30, 1915,	–	–	$899 77

Mary Robinson Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
Amherst Savings Bank,	$142 00	$142 00	$1 42
Boston & Albany Railroad stock, ⅜ share, at $187,	70 13	38 00	3 32
Electric Securities Company bonds, $\frac{41}{50}$ share, at $1,000,	779 00	820 00	41 00
	$991 13	$1,000 00	$45 74
Unexpended balance Dec. 1, 1914,	–	–	155 89
	–	–	$201 63
Investment of fund for fiscal year ending Nov. 30, 1915,	–	–	142 00
Cash on hand Nov. 30, 1915,	–	–	$59 63

Grinnell Prize Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
Ten shares New York Central & Hudson River Railroad stock, at $102,	$1,020 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1914,	–	–	195 74
	$1,020 00	$1,000 00	$245 74
Disbursements for prizes,	–	–	50 00
Cash on hand Nov. 30, 1915,	–	–	$195 74

Gassett Scholarship Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
One bond New York Central & Hudson River Railroad debenture 4s,	$930 00	$1,000 00	$40 00
Amherst Savings Bank, deposit,	11 64	11 64	46
	$941 64	$1,011 64	$40 46
Unexpended balance Dec. 1, 1914,	–	–	101 85
Cash on hand Nov. 30, 1915,	–	–	$142 31

SPECIAL FUNDS — *Concluded.*

Massachusetts Agricultural College (Investment).

	Market Value Dec. 1, 1915.	Par Value.	Income.
One share New York Central & Hudson River Railroad stock,	$102 00	$100 00	$5 00
Unexpended balance Dec. 1, 1914,	–	–	70 45
Cash on hand Nov. 30, 1915,	–	–	$75 45

Danforth Keyes Bangs Fund.

		Market Value Dec. 1, 1915.	Par Value.	Income.
Two bonds Pacific Telephone and Telegraph Company 5s, at $990,		$1,980 00	$2,000 00	$100 00
Two bonds Union Electric Light and Power Company 5s, at $980,		1,960 00	2,000 00	100 00
Two bonds American Telephone and Telegraph Company 4s, at $910,		1,820 00	2,000 00	80 00
Interest from student loans,		–	–	35 41
		$5,760 00	$6,000 00	$315 41
Unexpended balance Dec. 1, 1914,		–	–	381 21
		–	–	$696 62
Total loans made to students during fiscal year,	$1,503 00			
Cash received on account of student loans,	1,478 00			
Excess of loans made, over accounts paid by students,				25 00
Cash on hand Nov. 30, 1915,				$671 62

John C. Cutter Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
One bond Pacific Telephone and Telegraph Company 5s,	$990 00	$1,000 00	$50 00
Unexpended balance Dec. 1, 1914,	–	–	30 25
	$990 00	$1,000 00	$80 25
Disbursements for fiscal year to date,	–	–	32 41
Cash on hand Nov. 30, 1915,	–	–	$47 84

William R. Sessions Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
One bond New York Central & Hudson River Railroad stock 6s,	$555 00	$500 00	$15 00
Amherst Savings Bank, deposit,	2,500 00	2,500 00	–
	$3,055 00	$3,000 00	–
Cash on hand Nov. 30, 1915,	–	–	$15 00

Alvord Dairy Scholarship Fund.

	Market Value Dec. 1, 1915.	Par Value.	Income.
Amherst Savings Bank, deposit,	$4,000 00	$4,000 00	–
Overdraft Nov. 30, 1915,[1]	–	–	$600 00
	$4,000 00	$4,000 00	$600 00

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[1] Expense incurred in securing fund.

SUMMARY OF BALANCES ON HAND OF THE INCOME FROM FUNDS HELD IN TRUST BY THE MASSACHUSETTS AGRICULTURAL COLLEGE.

Burnham emergency,	$320 55
Endowed labor fund,	230 97
Whiting Street scholarship fund,	187 67
Hills fund,	899 77
Mary Robinson fund,	59 63
Grinnell prize fund,	195 74
Gassett scholarship fund,	142 31
Massachusetts Agricultural College investment fund,	75 45
Danforth Keyes Bangs fund,	671 62
John C. Cutter fund,	47 84
Wm. R. Sessions fund,	15 00
	$2,841 55
Alvord dairy scholarship fund overdraft,	600 00
	$2,241 55

I hereby certify that I have this day examined the Massachusetts Agricultural College account, as reported by the treasurer, Fred C. Kenney, for the year ending Nov. 30, 1915. All bonds and investments are as represented in the treasurer's report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

DEC. 8, 1915.

HISTORY OF SPECIAL FUNDS.

Burnham emergency fund: —	
A bequest of $5,000 from T. O. H. P. Burnham of Boston, made without any conditions. The trustees of the college directed that $1,000 of this fund should be used in the purchase of the Newell land and Goessmann library. The fund now shows an investment of	$4,000 00
Library fund: —	
The library of the college at the present time contains about 48,411 volumes. The income from the fund raised by the alumni and others is devoted to its increase, and additions are made from time to time as the needs of the different departments require. Dec. 27, 1883, William Knowlton gave $2,000; Jan. 1, 1894, Charles L. Flint gave $1,000; in 1887, Elizur Smith of Lee, Mass., gave $1,215. These were the largest bequests, and now amount to	10,000 00
Endowed labor fund: —	
Gift of a friend of the college in 1901, income of which is to be used for the assistance of needy and deserving students,	5,000 00

Whiting Street scholarship: —	
Gift of Whiting Street of Northampton, for no special purpose, but to be invested and the income used. This fund is now used exclusively for scholarship, . . .	$1,000 00
Hills fund: —	
Gift of Leonard M. and Henry F. Hills of Amherst, Mass., in 1867, to establish and maintain a botanic garden,	10,000 00
Mary Robinson fund: —	
Gift of Miss Mary Robinson of Medfield, in 1874, for scholarship, ...	1,000 00
Grinnell prize fund: —	
Gift of Hon. Wm. Claflin, to be known as the Grinnell agricultural prize, to be given to the two members of the graduating class who may pass the best oral and written examination in theory and practice of agriculture, given in honor of George B. Grinnell of New York, . . .	1,000 00
Gassett scholarship fund: —	
Gift of Henry Gassett of Boston, the income to be used for scholarship, ...	1,000 00
Massachusetts Agricultural College investment fund: —	
Investment made by vote of trustees in 1893 to purchase one share of New York Central & Hudson River Railroad stock. The income from this fund has been allowed to accumulate, ...	100 00
Danforth Keyes Bangs fund: —	
Gift of Louisa A. Baker of Amherst, Mass., April 14, 1909, the income thereof to be used annually in aiding poor, industrious and deserving students to obtain an education in said college, ...	6,000 00
John C. Cutter fund: —	
Gift of Dr. John C. Cutter of Worcester, Mass., an alumnus of the college, who died in August, 1909, to be invested by the trustees, and the income to be annually used for the purchase of books on hygiene, ...	1,000 00
Alvord dairy scholarship fund: —	
Gift of Henry E. Alvord, who was the first instructor in military tactics, 1869–71, and a professor of agriculture, 1885–87, at this institution. The income of this fund is to be applied to the support of any worthy student of said college, graduate or post-graduate, who may be making a specialty of the study of dairy husbandry (broadly considered), with the intention of becoming an investigator, teacher or special practitioner in connection with the dairy industry, provided that no benefits arising from such fund shall at any time be applied to any person who then uses tobacco in any form or fermented or spirituous beverages, or is known to have done so within one year next preceding, . .	4,000 00

William R. Sessions fund: —

In accordance with the request of my deceased wife, Clara Markham Sessions, made in her last will, I bequeath to the trustees of the Massachusetts Agricultural College, Amherst, Mass., the sum of $5,000, it being the amount received by me from the estate of the said Clara Markham Sessions. The said $5,000 to be kept by the said trustees a perpetual fund, the income from which shall be for the use of the Massachusetts Agricultural College; and according to the further request of my deceased wife, made in her last will, this is to be known as the William R. Sessions fund, and is to be a memorial of William R. Sessions; and it is my special request that the said trustees shall make record of the fact that this fund came from the estate of my deceased wife, Clara Markham Sessions, in accordance with her request made in her last will, ...	$5,000 00
	$49,100 00

Prizes.

Animal husbandry. The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago. Given in May, 1912, available first in autumn of 1912, and for the four succeeding years,	$150 00

FRED C. KENNEY,
Treasurer.

In Memoriam.

WILLIAM H. BOWKER.

Mr. William H. Bowker of the Board of Trustees died in Boston, Jan. 4, 1916. The trustees, in passing memorial resolutions, expressed the wish to have them incorporated in the report of the president and other officers for the fiscal year 1915. The memorial is as follows: —

Tribute adopted by the Trustees of Massachusetts Agricultural College, at Boston, Jan. 7, 1916.

Our associate William Henry Bowker, senior member of this Board in years of service, died at his home in Boston three days ago.

Born July 3, 1850, at Natick, and taught in the public schools of Phillipston and Templeton, he was a member of the first, the "pioneer," class of students received at the Massachusetts Agricultural College Oct. 2, 1867, and was graduated there July 19, 1871.

After about two years given to teaching and newspaper work, he founded, on new and untried lines, the business that by various stages grew into the large, successful and dominant work of his life, — the making and merchandizing of fertilizers and allied products. In the technical and commercial aspects of that business he became an acknowledged authority.

He set up for himself and his associates high standards of honor and accountability, and was a potent factor in promoting, through legislative regulation and otherwise, the policy and practice of the *open hand* in dealings between manufacturer and consumer.

Always from his student days an ardent friend of the college, and perhaps the most resourceful and effective worker and leader in its behalf among its alumni, he became in January, 1885, a member of this Board, *as the first one appointed by the Governor* of the Commonwealth, under legislation that sprung from his own early suggestion and efforts to reform the tenure of its membership and terminate its own self-elective functions.

He was conservative by family heritage and home influence, democratic, large-hearted, a lover of manly men and popular among his fellows. His mental traits, ripened through wide and intimate contact with men and affairs and by much reading and travel, were marked by breadth of view, originality of ideas and independence of thought, which, with a natural aptness of expression and power of effective statement, made him interesting in conversation and discourse and forcible in controversy.

With intimates his speech was well-nigh as frank and free as his thought; often leavened with humor, always (when in health) with good nature; and if in discussing real issues to be faced and placed he sometimes urged his view or criticised an opposing one with an apparent excess of ardor, it was due, not to lack of human kindness and sympathy in his make up, but rather to keen interest, ample courage and faith in his cause. Withal, he was equally ready to concede points scored by an opponent, and left no sting in the hearts of those with whom he differed.

He has now laid down in honor and loyalty, at the feet of his alma mater and of the Commonwealth, the burden and the harvest that go with high privilege and duty done, after the longest term of service given by any present or former member of this Board; and was himself conspicuous in making that period the richest and most fruitful in the history of the college he loved so well.

The Personal Word.

I often feel that in this institution the relation between the president and the trustees is almost ideal. Mr. Bowker, because of his forceful personality, his fertility in ideas, his quick appreciation of situations, his breadth of view, his long connection with the institution in various capacities, and his continued membership on trustee committees that dealt with important policies, was a wise, helpful and sympathetic counselor. I went to him frequently. It is difficult to express with restraint the obligation that I owe him, both officially and personally. I know that by all of us, trustees and faculty, his loss will be keenly felt, not only because of the choice personal element that entered into all our counsels, but because of the value of his contribution to our common work.

KENYON L. BUTTERFIELD.

THE M. A. C. BULLETIN
AMHERST, MASS.

Vol. VIII. No. 1. For January, 1916

Published Six Times a Year by the College.
Jan., Feb., Mar., May, Sept., Oct.

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Public Document No. 31

CATALOGUE

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

1915-1916.

FIFTY-THIRD ANNUAL REPORT.

PART II.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1916.

> Without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. — *Act of Congress, July 2, 1862.*

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST.

CATALOGUE, 1915-1916.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1916.

APPROVED BY
THE STATE BOARD OF PUBLICATION.

THE MASSACHUSETTS AGRICULTURAL COLLEGE.

This issue of the catalogue represents the status of the college for the current college year, with provisional announcement of courses of study and other matters for the year to follow. Additional announcements are made in a supplementary bulletin, published in the spring. Beginning September, 1916, the work of the college will be given in four terms instead of two semesters; full announcements will appear in the spring supplement.

The college reserves, for itself and its departments, the right to withdraw or change the announcements made in its catalogue. Special publication will be made should it become necessary on account of important changes.

CALENDAR.

1916-17.

REGULAR COURSES.

1916.

January 3, Monday, 1 P.M.,	Winter recess ends; regular schedule of classes.
February 7, Monday, 1 P.M.,	Second semester begins; regular schedule of classes.
February 22, Tuesday afternoon,	Half holiday, Washington's Birthday.
March 24, Friday, 5 P.M.,	Spring recess begins.
April 3, Monday, 1 P.M.,	Spring recess ends; regular schedule of classes.
April 19, Wednesday afternoon,	Half holiday, Patriots' Day.
May 30, Tuesday,	Holiday, Memorial Day.
June 17–21, Saturday–Wednesday,	Commencement.
June 22–24, Thursday–Saturday,	Entrance examinations.
September 13–16, Wednesday–Saturday,	Entrance examinations.
September 20, Wednesday, 1.30 P.M.,	Fall term begins; chapel.
October 12, Thursday afternoon,	Half holiday, Columbus Day.
November 29, Wednesday, 12 M.–Friday, December 1, 1 P.M.,	Thanksgiving recess.
December 15, Friday, 5 P.M.,	Winter term closes; Christmas recess begins.

1917.

January 1, Monday, 1 P.M.,	Christmas recess ends; winter term begins.
February 22, Thursday afternoon,	Half holiday, Washington's Birthday.
March 23, Friday, 5 P.M.,	Winter term closes; spring recess begins.
April 2, Monday, 1 P.M.,	Spring recess ends; spring term begins.
April 19, Thursday afternoon,	Half holiday, Patriots' Day.
May 30, Wednesday,	Holiday, Memorial Day.
June 23–27, Saturday–Wednesday,	Commencement.
June 27, Wednesday,	Spring term ends.
July 2, Monday,	Summer term begins.

MASSACHUSETTS AGRICULTURAL COLLEGE.

HISTORY. — The Massachusetts Agricultural College was among the first of those organized under the national land grant act of 1862. This act granted public lands to the several States and Territories, the funds realized from the sale of which should be used to establish colleges of agriculture and mechanic arts; the bill was framed by the late Senator Justin Smith Morrill of Vermont. The Legislature of Massachusetts has granted money for the erection of nearly all the buildings now on the grounds, and makes annual appropriations for the maintenance of the college.

The college was incorporated in 1863, and on the 2d of October, 1867, was formally opened to its first class of students. At that time four buildings had been erected, and there were four regular instructors employed by the institution. In 1882 the State located its agricultural experiment station on the grounds of the college. Later, after the Federal law was passed granting financial aid to experiment stations, the Massachusetts Agricultural Experiment Station was consolidated with the Federal station, and subsequently the whole was incorporated with the college.

COURSES. — The college offers an education without tuition fee to any student who is a resident of Massachusetts and who meets the requirements for admission. Women are admitted on the same basis as are men. Students who are not residents of Massachusetts are required to pay a nominal tuition fee. The four-year[1] course leads to the degree of bachelor of science, and the graduate school offers advanced courses leading to the degrees of master of science, doctor of philosophy and master of agriculture. The winter school of ten weeks, for admission to which no scholastic requirements are made, is held each winter, beginning early in January. There are other short courses at the college, such as the beekeepers' course and summer school. Various forms of extension teaching are carried on away from the college, such as correspondence courses, traveling schools, educational exhibits, lecture courses, demonstrations and circulating libraries.

PURPOSE OF THE COLLEGE. — The chief purpose of the college is to prepare men and women for the agricultural vocations. In this statement the term "agricultural vocations" is used in its broadest sense. Courses are offered which give efficient training in various agricultural pursuits, such as general farming, dairying, management of estates, poultry husbandry, fruit growing, market gardening, landscape gardening and forestry. Students are also fitted for positions in institutions designed for investigation in many sciences underlying the great agricultural industry, for teaching in agricultural colleges and high schools, for scientific experts in chemistry, entomology, botany and microbiology and for business operations having connection with practical agriculture.

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[1] Twenty-seven teaching departments offer instruction in agriculture, horticulture, sciences, the humanities and rural social science. A system of major courses permits a student to elect major work in 1 of 16 departments, specializing in that and allied subjects for a period of two years.

Though the agricultural vocations are thus the chief concern of the college, students also find the course one that fits them admirably for pursuits in which the sciences, particularly chemistry, botany and zoölogy, are an essential preparation. Still other students find the course a desirable education, without regard to future occupation. The course of study is designed to give a student a general college education, and in addition to make it possible for him to specialize in any department in which a major course is offered.

Location and Equipment. — The agricultural college is located in the town of Amherst. The grounds comprise more than 600 acres, lying about a mile north of the village center. The equipment of the college, both in buildings and facilities for instruction, is excellent. Amherst is about 98 miles from Boston, and may be reached over the Central Massachusetts division of the Boston & Maine Railroad, or by way of the Central Vermont Railroad. Electric car lines connect Amherst with Northampton, Holyoke and Springfield.

THE MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

Massachusetts provided for the establishment of an agricultural experiment station in 1882. This station, though on the college grounds and supported by the State, was then without organic connection with the college. Under an act of Congress, passed in 1887, an agricultural experiment station was established as a department of the college, and was supported by the general government. For a time, therefore, Massachusetts had two experiment stations at the college. In 1894 these were combined, and the station reorganized as a department of the college. It is now supported by funds from both the State and the general government. In 1906 the general government largely increased its support of experiment stations, on condition, however, that the money thus provided should be used only for research. The station now receives about one-third of its support from the State.

The station is under the direct supervision of the Board of Trustees. The chief officer is the director, who is responsible to the president and to a committee of the Board. The station is organized into a number of departments, all co-operating toward the betterment of agriculture. In most cases the heads of the station departments are heads of corresponding departments in the college. The work of the station takes three directions; namely, control work, experimentation and investigation. The station publishes numerous bulletins and two annual reports, one scientific, the other for practical farmers and for general distribution. These publications, conveying information as to results of experiments, are free, and circulate extensively, the mailing list containing some 20,000 addresses.

THE CORPORATION.

ORGANIZATION OF 1915.

MEMBERS OF THE CORPORATION.

	TERM EXPIRES
ARTHUR G. POLLARD of Lowell,	1916
CHARLES A. GLEASON of New Braintree,	1916
FRANK GERRETT of Greenfield,	1917
HAROLD L. FROST of Arlington,	1917
CHARLES H. PRESTON of Danvers,	1918
FRANK A. HOSMER of Amherst,	1918
DAVIS R. DEWEY of Cambridge,	1919
JOHN F. GANNON of Worcester,	1919
WILLIAM H. BOWKER of Concord,	1920
GEORGE H. ELLIS of West Newton,	1920
ELMER D. HOWE of Marlborough,	1921
EDMUND MORTIMER of Grafton,	1921
NATHANIEL I. BOWDITCH of Framingham,	1922
WILLIAM WHEELER of Concord,	1922

MEMBERS EX OFFICIO.

His Excellency Governor DAVID I. WALSH, *President of the Corporation.*
KENYON L. BUTTERFIELD, *President of the College.*
DAVID SNEDDEN, *State Commissioner of Education.*
WILFRID WHEELER, *Secretary of the State Board of Agriculture.*

OFFICERS OF THE CORPORATION.

His Excellency Governor DAVID I. WALSH of Boston, *President.*
CHARLES A. GLEASON of New Braintree, *Vice-President.*
WILFRID WHEELER of Concord, *Secretary.*
FRED C. KENNEY of Amherst, *Treasurer.*
CHARLES A. GLEASON of New Braintree, *Auditor.*

STANDING COMMITTEES OF THE CORPORATION.[1]

Committee on Finance.

CHARLES A. GLEASON, *Chairman.*
GEORGE H. ELLIS.
NATHANIEL I. BOWDITCH.
ARTHUR G. POLLARD.
FRANK A. HOSMER.
EDMUND MORTIMER.

Committee on Course of Study and Faculty.

WILLIAM WHEELER, *Chairman.*
WILLIAM H. BOWKER.
FRANK A. HOSMER.
DAVID SNEDDEN.
ELMER D. HOWE.
DAVIS R. DEWEY.
JOHN F. GANNON.

Committee on Farm.

NATHANIEL I. BOWDITCH, *Chairman.*
FRANK GERRETT.
CHARLES A. GLEASON.
GEORGE H. ELLIS.

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[1] The president of the college is ex officio member and secretary of standing committees.

Committee on Horticulture.

Harold L. Frost, *Chairman.*
Edmund Mortimer.
Elmer D. Howe.
Wilfrid Wheeler.

Committee on Experiment Department.[1]

Charles H. Preston, *Chairman.*
Wilfrid Wheeler.
Arthur G. Pollard.
Harold L. Frost.
Edmund Mortimer.

Committee on Buildings and Arrangement of Grounds.

William H. Bowker, *Chairman.*
William Wheeler.
Frank Gerrett.
Charles H. Preston.
George H. Ellis.

Committee on Extension Service.

Elmer D. Howe, *Chairman.*
George H. Ellis.
Harold L. Frost.
Davis R. Dewey.
Wilfrid Wheeler.
John F. Gannon.

Examining Committee of Overseers from the State Board of Agriculture.

John Bursley of West Barnstable.
Frank P. Newkirk of Easthampton.
William E. Patrick of Warren.
John J. Erwin of Wayland.
Charles W. Freehan, of Great Barrington.

ORGANIZATION OF 1916.

Members of the Corporation.

	TERM EXPIRES
Frank Gerrett of Greenfield,	1917
Harold L. Frost of Arlington,	1917
Charles H. Preston of Danvers,	1918
Frank A. Hosmer of Amherst,	1918
Davis R. Dewey of Cambridge,	1919
John F. Gannon of Worcester,	1919
Arthur G. Pollard of Lowell,	1920
George H. Ellis of West Newton,	1920
Elmer D. Howe of Marlborough,	1921
Edmund Mortimer of Grafton,	1921
Nathaniel I. Bowditch of Framingham,	1922
William Wheeler of Concord,	1922
Charles A. Gleason of New Braintree,	1923
James F. Bacon of Boston,	1923

Members Ex Officio.

His Excellency Governor Samuel W. McCall, *President of the Corporation.*
Kenyon L. Butterfield, *President of the College.*
David Snedden, *State Commissioner of Education.*
Wilfrid Wheeler, *Secretary of the State Board of Agriculture.*

Officers of the Corporation.

His Excellency Governor Samuel W. McCall of Boston, *President.*
Charles A. Gleason of New Braintree, *Vice-President.*
Wilfrid Wheeler of Concord, *Secretary.*
Fred C. Kenney of Amherst, *Treasurer.*
Charles A. Gleason of New Braintree, *Auditor.*

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[1] The director of the experiment station is a member of the committee on experiment department, without vote.

Standing Committees of the Corporation.

Committee on Finance.

Charles A. Gleason, *Chairman.*
George H. Ellis.
Nathaniel I. Bowditch.
Arthur G. Pollard.
Frank A. Hosmer.
Edmund Mortimer.

Committee on Course of Study and Faculty.

William Wheeler, *Chairman.*
Frank A. Hosmer.
Elmer D. Howe.
David Snedden.
Davis R. Dewey.
John F. Gannon.
James A. Bacon.

Committee on Farm.

Nathaniel I. Bowditch, *Chairman.*
Frank Gerrett.
George H. Ellis.
Edmund Mortimer.

Committee on Horticulture.

Harold L. Frost, *Chairman.*
Charles A. Gleason.
Elmer D. Howe.
Wilfrid Wheeler.

Committee on Experiment Department.

Charles H. Preston, *Chairman.*
Wilfrid Wheeler.
Arthur G. Pollard.
Harold L. Frost.
Edmund Mortimer.

Committee on Buildings and Arrangement of Grounds.

Frank Gerrett, *Chairman.*
William Wheeler.
Charles H. Preston.
George H. Ellis.
James F. Bacon.

Committee on Extension Service.

Elmer D. Howe, *Chairman.*
George H. Ellis.
Harold L. Frost.
Davis R. Dewey.
Wilfrid Wheeler.
John F. Gannon.

Examining Committee of Overseers from the State Board of Agriculture.

John Bursley of West Barnstable.
Frank P. Newkirk of Easthampton.
William E. Patrick of Warren.
John J. Erwin of Wayland.
Charles W. Freehan of Great Barrington.

OFFICERS OF THE INSTITUTION.

[The names of the faculty are arranged in groups according to rank. Within these groups, the order depends upon seniority of service in the college, not upon seniority of appointment to the position now held.]

THE FACULTY.

Kenyon L. Butterfield, A.M., LL.D., President of the College and Head of Division of Rural Social Science.	President's House.
Charles H. Fernald, Ph.D., Honorary Director of the Graduate School.	3 Hallock Street.
Edward M. Lewis, A.M., Dean of the College and Professor of Languages and Literature.	19 Lincoln Avenue.
Fred C. Kenney, Treasurer of the College.	Mount Pleasant.
William P. Brooks, Ph.D., Director of the Experiment Station and Lecturer on Soil Fertility.	6 Farview Way.
William D. Hurd, M.Agr., Director of the Extension Service and Supervisor of Short Courses.	46 Amity Street.
Charles E. Marshall, Ph.D., Director of the Graduate School and Professor of Microbiology.	44 Sunset Avenue.
Frank A. Waugh, M.Sc., Head of Division of Horticulture and Professor of Landscape Gardening.	Campus.
James A. Foord, M.Sc.Agr., Head of Division of Agriculture and Professor of Farm Administration.	54 Lincoln Avenue.
Robert J. Sprague, Ph.D., Head of Division of Humanities and Professor of Economics and Sociology.	Mount Pleasant.
Joseph B. Lindsey, Ph.D., Goessmann Professor of Chemistry.	47 Lincoln Avenue.
Charles Wellington, Ph.D., Professor of Chemistry.	34 Amity Street.
James B. Paige, B.Sc., D.V.S., Professor of Veterinary Science.	42 Lincoln Avenue.
George E. Stone,[1] Ph.D., Professor of Botany.	Mount Pleasant.
Philip B. Hasbrouck, B.Sc., Registrar of the College and Professor of Physics.	130 Pleasant Street.
John E. Ostrander, A.M., C.E., Professor of Mathematics and Civil Engineering.	33 North Prospect Street.
Henry T. Fernald, Ph.D., Professor of Entomology, Chairman of Division of Science.	44 Amity Street.
Sidney B. Haskell, B.Sc., Professor of Agronomy.	North Amherst.
William R. Hart, A.M., L.B., Professor of Agricultural Education.	97 Pleasant Street.
Fred C. Sears, M.Sc., Professor of Pomology.	Mount Pleasant.
William P. B. Lockwood, M.Sc., Professor of Dairying.	34 North Prospect Street.

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[1] On account of ill health not in administrative charge; Associate Professor Osmun acting as head of department.

Alexander E. Cance, Ph.D., . . . 9 Fearing Street.
Professor of Agricultural Economics and Supervisor of Agricultural Surveys.

Joseph S. Chamberlain, Ph.D., . . . Mount Pleasant.
Professor of Organic and Agricultural Chemistry.

John C. Graham, B.Sc.Agr., . . . Lincoln Avenue.
Professor of Poultry Husbandry.

G. Chester Crampton, Ph.D., . . . 86 Pleasant Street.
Professor of Insect Morphology.

William D. Clark, A.B., M.F., . . . 3 Mount Pleasant.
Professor of Forestry.

Christian I. Gunness, B.Sc., . . . 105 Butterfield Avenue.
Professor of Rural Engineering.

Henry W. Fleet, Lieutenant, U. S. A., . . . 5 Phillips Street.
Professor of Military Science and Tactics.

Harold F. Tompson, B.Sc., . . . 10 Temple Street, Arlington.
Professor of Market Gardening.

John Phelan, A.M., . . . 5 Allen Street.
Professor of Rural Sociology.

John C. McNutt,[1] B.Sc.Agr., . . . 5 School Street.
Professor of Animal Husbandry.

A. Vincent Osmun, M.Sc., . . . Kendrick Place.
Associate Professor of Botany.

Clarence E. Gordon, Ph.D., . . . 38 Lincoln Avenue.
Associate Professor of Zoölogy and Geology.

Robert W. Neal, A.M., . . . Box 708, Amherst.
Associate Professor of English.

Edgar L. Ashley, A.M., . . . 24 Pleasant Street.
Associate Professor of German.

Alexander A. Mackimmie, A.M., . . . North Amherst.
Associate Professor of French.

Burton N. Gates, Ph.D., . . . 42 Lincoln Avenue.
Associate Professor of Beekeeping.

John A. McLean,[2] A.B., B.Sc.Agr., . . . – –
Associate Professor of Animal Husbandry.

Charles A. Peters, Ph.D., . . . 2 South Sunset Avenue.
Associate Professor of Inorganic and Soil Chemistry.

George E. Gage, Ph.D., . . . 27 Sunset Avenue.
Associate Professor of Animal Pathology.

Curry S. Hicks, B.Pd., . . . 8 Allen Street.
Associate Professor of Physical Education and Hygiene.

Ernest Anderson, Ph.D., . . . 3 Phillips Street.
Associate Professor of General and Physical Chemistry.

Walter W. Chenoweth, A.B., M.Sc., . . . North Amherst.
Associate Professor of Pomology.

F. H. Hesselink van Suchtelen, Ph.D., . . . 30 North Prospect Street.
Associate Professor of Microbiology.

Arno H. Nehrling, . . . 24 Pleasant Street.
Associate Professor of Floriculture.

Ralph J. Watts, B.Sc., . . . 10 Nutting Avenue.
Secretary of the College.

Charles R. Green, B.Agr., . . . Mount Pleasant.
Librarian.

C. Robert Duncan, B.Sc., C.E., . . . 23 Lincoln Avenue.
Assistant Professor of Mathematics.

Arthur K. Harrison, . . . 8 Allen Street.
Assistant Professor of Landscape Gardening.

Elvin L. Quaife, B.Sc.Agr., . . . 103 Butterfield Avenue.
Assistant Professor of Animal Husbandry.

William L. Machmer, A.M., M.E., . . . 3 Kendrick Place.
Assistant Professor of Mathematics.

Henry E. Smith, A.M., . . . 24 Pleasant Street.
Assistant Professor of English.

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[1] Services began Jan. 1, 1916.

[2] Resigned Sept. 30, 1915.

Walter E. Prince, Ph.B., A.M., Assistant Professor of English.	Kendrick Place.
Harold E. Robbins, B.Sc., A.M., Assistant Professor of Physics.	12 Nutting Avenue.
Paul J. Anderson, Ph.D., Assistant Professor of Botany.	24 Pleasant Street.
Earl Jones, M.Sc., Assistant Professor of Agronomy.	24 Pleasant Street.
Charles H. Thompson, M.Sc., Assistant Professor of Horticulture.	77 South Pleasant Street.
Andrew S. Thomson, Ph.B., Assistant Professor of Market Gardening.	10½ Kellogg Avenue.
Orville A. Jamison, B.Sc., Assistant Professor of Dairying.	7 East Pleasant Street.
Frank W. Rane, M.F., Lecturer in Forestry.	Boston.
Helena T. Goessmann, M.Ph., Instructor in English.	13 Main Street.
William L. Harmount, A.B., Instructor in French.	86 Pleasant Street.
Arthur N. Julian, A.B., Instructor in German.	Farview Way.
Frederick A. McLaughlin, B.Sc., Instructor in Botany.	24 Pleasant Street.
Samuel Coons, Instructor in Dairying.	2 McClellan Street.
Frank N. Blanchard, A.B., Instructor in Zoölogy and Geology.	23 Lincoln Avenue.
Loyal F. Payne, B.Sc., Instructor in Poultry Husbandry.	12 Chestnut Street.
William S. Regan, Ph.D., Instructor in Entomology.	6 Allen Street.
Frank P. Rand, A.B., Instructor in English.	24 Pleasant Street.
Harold E. Baldinger, B.Sc., Instructor in Dairying.	4 North Prospect Street.
Walter M. Peacock,[1] B.Sc., Instructor in Farm Management.	24 Pleasant Street.
Glenn J. Wight,[2] B.Sc., Instructor in Animal Husbandry.	Lincoln Building, Main Street.
Raymond G. Smith, B.Sc., Assistant in Botany.	Savings Bank Block.
William J. Fitzmaurice, Assistant in Physical Education.	– –
Harold M. Gore, B.Sc., Assistant in Physical Education.	8 Allen Street.
Burt A. Hazeltine, B.Sc., Assistant in Mathematics.	4 North Prospect Street.
Arao Itano, B.Sc., Assistant in Microbiology.	Lincoln Building, Main Street.
Paul Serex, Jr., B.Sc., Assistant in Chemistry.	M. A. C.
Frederick G. Merkle, B.Sc., Assistant in Agronomy.	East Street.
Harry C. Thompson, B.Sc., Assistant in Physics.	16 North Prospect Street.
Frederick W. Read, B.Sc., Assistant in Agricultural Economics.	84 Pleasant Street.

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[1] Services began Jan. 1, 1916.

[2] Temporary appointment.

Graduate Assistants.

Robert P. Armstrong, B.Sc., Department of Pomology, Experiment Station.	Phi Sigma Kappa House.
Roy C. Avery, B.Sc., Department of Microbiology.	17 Phillips Street.
Charles G. Baird, A.M., Department of Rural Sociology.	23 Lincoln Avenue.
J. Stanley Cobb, B.Sc., Department of Agronomy.	5 Allen Street.
William L. Doran, B.Sc., Department of Botany.	Clark Hall.
Alexander J. Erichson, B.Sc., Department of Chemistry.	4 North Prospect Street.
Ernest E. Fish, B.Sc., Department of Animal Husbandry.	5 Allen Street.
Egerton G. Hood, B.Sc., Industrial Tests, Experiment Station.	15 Spring Street.
Russell F. Lund, A.B., Department of Rural Sociology.	Pine Heights.
Ralph L. MacNeil, B.Sc., Department of Chemistry.	M. A. C.
William T. Payne, B.Sc., Industrial Tests, Experiment Station.	12 Chestnut Street.
Gerald E. Perry, B.Sc., Department of Chemistry.	19 Amity Street.
Arthur W. Phillips, B.Sc., Department of Chemistry.	4 North Prospect Street.
Irving C. Root, B.Sc., Department of Landscape Gardening.	Mount Pleasant.
Carl J. Strand, A.M., Department of Agricultural Economics.	75 Pleasant Street.
Arthur S. Thurston, B.Sc., Department of Floriculture.	9 Fearing Street.
Donald White, B.Sc., Department of Poultry Husbandry, Experiment Station.	16 North Prospect Street.
Stuart C. Vinal, B.Sc., Department of Entomology, Experiment Station.	112 Pleasant Street.

THE EXPERIMENT STATION STAFF.

Administration.

William P. Brooks, Ph.D., Director.	6 Farview Way.
Joseph B. Lindsey, Ph.D., Vice-Director.	47 Lincoln Avenue.
Fred C. Kenney, Treasurer.	Mount Pleasant.
Charles R. Green, B.Agr., Librarian.	Mount Pleasant.

Department of Agriculture.

William P. Brooks, Ph.D., Agriculturist.	6 Farview Way.
Henry J. Franklin, Ph.D., In charge of Cranberry Investigation.	Wareham.
Edwin F. Gaskill, B.Sc., Assistant Agriculturist.	North Pleasant Street.
Robert L. Coffin, Assistant.	Farview Way.

Department of Botany and Vegetable Pathology.

George E. Stone,[1] Ph.D., Botanist and Plant Pathologist.	Mount Pleasant.
George H. Chapman, M.Sc., Assistant Botanist.	13 Fearing Street.
Orton L. Clark, B.Sc., Assistant Botanist.	Mount Pleasant.

Department of Entomology.

Henry T. Fernald, Ph.D., Entomologist.	44 Amity Street.
Burton N. Gates, Ph.D., Apiarist.	42 Lincoln Avenue.
Arthur I. Bourne, A.B., Assistant Entomologist.	12 East Pleasant Street.

Department of Plant and Animal Chemistry.

Joseph B. Lindsey, Ph.D., Chemist.	47 Lincoln Avenue.
Edward B. Holland, Ph.D., Associate Chemist, in charge of Research Division.	28 North Prospect Street.
Fred W. Morse, M.Sc., Research Chemist.	40 Pleasant Street.
Henri D. Haskins, B.Sc., In charge of Fertilizer Division.	14 Amity Street.
Philip H. Smith, M.Sc., In charge of Feed and Dairy Division.	102 Main Street.
Lewell S. Walker, B.Sc., Assistant.	19 Phillips Street.
Rudolph W. Ruprecht,[2] M.Sc., Assistant.	– –
Carlton P. Jones, M.Sc., Assistant.	30 North Prospect Street.
Carlos L. Beals, B.Sc., Assistant.	Kendrick Place.
Walter S. Frost,[3] B.Sc., Assistant.	– –
Charles W. Davis,[4] B.Sc., Assistant.	Kappa Sigma House.
James P. Buckley, Jr., B.Sc., Assistant.	29 Lincoln Avenue.
James T. Howard, Collector.	154 Main Street.
Harry L. Allen, Assistant.	89 Main Street.
James R. Alcock, Assistant.	North Amherst.

Department of Horticulture.

Frank A. Waugh, M.Sc., Horticulturist.	Campus.
Fred C. Sears, M.Sc., Pomologist.	Mount Pleasant.
Jacob K. Shaw, Ph.D., Research Pomologist.	1 Allen Street.

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[1] On account of ill health not in administrative charge; Associate Professor Osmun acting as head of Department of Botany.

[2] Absent on leave; position filled temporarily by Mr. Norman H. Borden.

[3] Resignation took effect Oct. 31, 1915.

[4] Services began Dec. 1, 1915.

Department of Meteorology.

John E. Ostrander, A.M., C.E., ... 33 North Prospect Street.
Meteorologist.

Department of Microbiology.

Charles E. Marshall, Ph.D., ... 44 Sunset Avenue.
In charge of Department.

F. H. Hesselink van Suchtelen, Ph.D., ... 30 North Prospect Street.
Associate Professor of Microbiology.

Department of Poultry Husbandry.

John C. Graham, B.Sc.Agr., ... Lincoln Avenue.
In charge of Department.

Hubert D. Goodale, Ph.D., ... North Amherst.
Research Biologist.

Department of Veterinary Science.

James B. Paige, B.Sc., D.V.S., ... 42 Lincoln Avenue.
Veterinarian.

George E. Gage, Ph.D., ... 27 Sunset Avenue.
Associate Professor of Animal Pathology.

Beryl H. Paige, A.B., ... 42 Lincoln Avenue.
Assistant in Veterinary Science.

Arnold P. Sturtevant, A.B., ... 41 Lincoln Avenue.
Assistant in Veterinary Science.

THE EXTENSION SERVICE STAFF.

William D. Hurd, M.Agr., ... 46 Amity Street.
Director of the Extension Service and Supervisor of Short Courses.

Earnest D. Waid, B.Sc.Agr., ... 61 Amity Street.
Assistant Director.

Sumner R. Parker,[1] B.Sc., ... 41 Amity Street.
Assistant State Leader and Extension Professor of Rural Organization.

Orion A. Morton, ... Lincoln Avenue.
Extension Professor of Agricultural Education.

Ezra L. Morgan, A.M., ... 2 Allen Street.
Extension Professor of Community Planning.

Laura Comstock, ... 84 Pleasant Street.
Extension Professor of Home Economics.

Richard H. Ferguson,[2] B.Sc.Agr., ... – –
Extension Professor of Agricultural Economics.

E. Farnam Damon,[3] B.Sc., ... – –
Extension Associate Professor of Agricultural Economics.

Ralph W. Rees, A.B., B.Sc., ... 24 Pleasant Street.
Extension Instructor in Pomology.

Frank A. C. Smith,[3] B.Sc., ... – –
Extension Instructor in Civic Improvement.

Erwin H. Forbush, ... 8 Nutting Avenue.
Supervisor of Correspondence Courses.

Ethel H. Nash, ... 16 Nutting Avenue.
Extension Instructor in Agricultural Education.

Benjamin W. Ellis,[4] B.Sc., ... – –
Assistant State Leader.

Harriet J. Hopkins,[5] B.Sc., ... – –
Extension Instructor in Home Economics.

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[1] Services began Dec. 6, 1915.

[2] Died Dec. 1, 1915.

[3] Services began Feb. –, 1916.

[4] Resignation took effect Dec. 31, 1915.

[5] Resignation took effect Oct. 6, 1915.

Alfred G. Lunn, B.Sc., ... North Amherst.
Extension Instructor in Poultry Husbandry.
Eric N. Boland, M.Sc., ... 13 Fearing Street.
Extension Instructor in charge of Boys' and Girls' Pig Club Work.
Marie Sayles,[1] B.Sc., ... 79 Pleasant Street.
Extension Instructor in Home Economics.
Wesley H. Bronson, B.Sc., ... Lincoln Block.
Extension Instructor in Farm Demonstrations.
William F. Turner,[2] B.Sc., ... – –
Extension Instructor in Animal Husbandry.

THE CLERICAL STAFF.

Elbert L. Arnold,[3] . . . . Northampton.
Chief Clerk, Extension Service.
Clarissa G. Babcock,[4] . . . . – –
Library Assistant.
Eleanor Barker,[5] . . . . 9 Phillips Street.
Clerk, Department of Floriculture.
Eleanor F. Bishop, ... 3 Spaulding Street.
Clerk, Treasurer's Office.
Frances C. Boynton, A.B., ... 10 Hallock Street.
Clerk, Department of Farm Administration.
John K. Broadfoot, ... 7½ East Pleasant Street.
Cashier, Treasurer's Office.
Bertha A. Brockhaus,[6] . . . . – –
Clerk, President's Office.
Anne Butler,[7] . . . . – –
Assistant in Library.
Mabel R. Case,[8] A.B., ... – –
First Clerk, Extension Service.
Ada M. Chandler, A.B., ... 3 Fearing Street.
Cataloguer, Library.
Lena V. Chapman, ... 77 South Pleasant Street.
Library Assistant.
Lucia G. Church, ... North Amherst.
First Clerk, Experiment Station.
Phyllis J. Cogswell, ... 79 Pleasant Street.
Stenographer, Department of Agricultural Education.
Jessie V. Crocker, ... Sunderland.
Clerk, Department of Botany.
Marcella P. Curry, B.Sc., ... Draper Hall.
Clerk, Department of Poultry Husbandry.
Louise G. Davidson,[9] . . . . 7 Northampton Road.
Telephone Operator, Stockbridge Hall.
F. Ethel Felton,[10] . . . . 8 Allen Street.
Clerk, Director's Office, Experiment Station.
Lina E. Fisher, ... 28 Pleasant Street.
Clerk, Department of Chemistry.
Grace E. Gallond, ... 28 Pleasant Street.
Clerk, Department of Dairying.
Lillian M. Gelinas, ... 77 Pleasant Street.
Clerk, President's Office.
Alice M. Gilbert, ... 9 Phillips Street.
First Clerk, Division of Agriculture.
Hannah M. Griffin, A.B., ... 9 Phillips Street.
Clerk, Department of Farm Administration.

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[1] Services began Sept. 16, 1915.
[2] Services began Dec. 8, 1915.
[3] Services began Jan. 14, 1916.
[4] Resignation took effect Sept. 30, 1915.
[5] Services began Dec. 13, 1915.
[6] Resignation took effect Dec. 31, 1915.
[7] Services began Oct. 18, 1915; resignation took effect Nov. 13, 1915.
[8] Resignation took effect Jan. 31, 1916.
[9] Services began Nov. 15, 1915.
[10] Services began Nov. 1, 1915.

Cora B. Grover,	Clerk, Director's Office, Extension Service.	North Amherst.
Marion Guertin,	Stenographer, Department of Beekeeping.	20 Pleasant Street.
Lillian S. Hadfield,	Clerk, Extension Service.	9 Phillips Street.
Laura W. Hager,[1] A.B.,	Clerk, Department of Agricultural Economics.	Deerfield.
Mary E. Horton,	Clerk, Department of Rural Social Science.	15 Fearing Street.
Esther L. Houghton, A.B.,	Clerk, Department of Microbiology.	Draper Hall.
Alice M. Howard,	First Clerk, Experiment Station.	North Amherst.
Lorian P. Jefferson, A.M.,	Research Secretary, Division of Rural Social Science.	84 Pleasant Street.
Helena Keiber,	Stenographer, Extension Service.	56 Pleasant Street.
Irene A. Martin,[2]	Stenographer, Treasurer's Office.	East Street.
Rebecca L. Mellor,	Clerk, Experiment Station.	10 Kellogg Avenue.
Nell C. Milton,	Stenographer, Division of Rural Social Science.	Draper Hall.
Elizabeth E. Mooney,	Stenographer, Department of Poultry Husbandry.	Draper Hall.
Bridie E. O'Donnell,	Clerk, Department of Entomology.	Hadley.
Helen C. Pomeroy,	Stenographer, Division of Horticulture.	Draper Hall.
Vivian Roy,[3]	Library Assistant.	5 McClellan Street.
Gladys E. Russell, A.B.,	Clerk, Division of Horticulture.	9 Phillips Street.
Edna M. Sanders,	Bookkeeper, Treasurer's Office.	Hadley.
Mary I. Shores,	Clerk, Dean's Office.	10 Woodside Avenue.
Elsa Slattery,	Stenographer, Extension Service.	Northampton.
Dorothy F. Smith,[4]	Clerk, Department of Floriculture.	– –
Harriet C. Stevenson,[5]	Stenographer, Department of Agricultural Economics.	– –
Ethel M. Turner,[6]	Library Assistant.	55 Pleasant Street.
Olive M. Turner, B.Sc.,	Clerk, Registrar's Office.	22 Spaulding Street.
Dorothy M. Tyacke,[7]	Stenographer, Treasurer's Office.	– –
Henrietta L. Webster,	First Clerk, Treasurer's Office.	Draper Hall.
Aurelia B. Wentworth,	Stenographer, Division of Agriculture.	South Amherst.

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[1] Services began Dec. 1, 1915.

[2] Services began Oct. 26, 1915.

[3] Services began Nov. 29, 1915.

[4] Resignation took effect Dec. 10, 1915.

[5] Resignation took effect Sept. 9, 1915.

[6] Services began Nov. 26, 1915.

[7] Resignation took effect Oct. 26, 1915.

STAFF OF OPERATING AND MAINTENANCE.

John J. Barber, Farm Superintendent.	Campus.
Thomas Butterworth, Assistant Engineer.	6 Phillips Street.
John L. Byard, Superintendent of the Apiary.	21 Pleasant Street.
William Chesley, Steward of the Dining Hall.	Draper Hall.
Lawrence S. Dickinson, B.Sc., Superintendent of Grounds.	2 Farview Way.
Clarence A. Jewett, Superintendent of Buildings.	112 Pleasant Street.
John J. Lee, Assistant to the Military Detail.	38 Cottage Street.
Florence Levensaler, Resident Nurse.	Infirmary.
Alexander Smart,[1] Assistant to the Commandant.	East Pleasant Street.
Newton Wallace, Electrician.	Campus.
James Whiting, Foreman, Department of Floriculture.	16 Hallock Street.

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[1] Services began Nov. 2, 1915.

STANDING COMMITTEES OF THE FACULTY.

1915-16.

CATALOGUE AND OTHER PUBLICATIONS.

Associate Professor NEAL.
Assistant Professor SMITH.
Secretary WATTS.

COMMENCEMENT.

Professor PAIGE.
Treasurer KENNEY.
Lieutenant FLEET.
Associate Professor PETERS.
Associate Professor NEHRLING.
Assistant Professor DUNCAN.
Secretary WATTS.

COURSE OF STUDY.

President BUTTERFIELD.
Dean LEWIS.
Professor HART.
Professor WAUGH.
Professor FOORD.
Professor SPRAGUE.
Professor FERNALD.
Professor OSTRANDER.
Professor MARSHALL.
Professor CHAMBERLAIN.
Professor CANCE.
Associate Professor CHENOWETH.

DISCIPLINE (ADVISORY).

Dean LEWIS.
Professor HASBROUCK.
Associate Professor HICKS.
Associate Professor MACKIMMIE.
Assistant Professor MACHMER.

EMPLOYMENT.

Professor SEARS.
Dean LEWIS.
Treasurer KENNEY.
Professor HASKELL.

ENTRANCE EXAMINATIONS AND ADMISSION.

Registrar HASBROUCK.
- Dean LEWIS.
- Associate Professor OSMUN.
- Associate Professor E. ANDERSON.
- Associate Professor ASHLEY.
- Assistant Professor MACHMER.

HEALTH AND SANITATION.

Professor MARSHALL.
- Treasurer KENNEY.
- Lieutenant FLEET.
- Professor LOCKWOOD.
- Miss COMSTOCK.
- Associate Professor HICKS.

LIBRARY.

Professor MARSHALL.
- Professor SPRAGUE.
- Professor GUNNESS.
- Assistant Professor A. S. THOMSON.
- Mr. GREEN.

SCHEDULE.

Professor LOCKWOOD.
- Associate Professor PETERS.
- Assistant Professor DUNCAN.

SCHOLARSHIP.

Dean LEWIS.
- Registrar HASBROUCK.
- Associate Professor GORDON.
- Associate Professor MACKIMMIE.
- Assistant Professor HARRISON.
- Assistant Professor MACHMER.

STUDENT LIFE.

President BUTTERFIELD.
- Dean LEWIS.
- Treasurer KENNEY.
- Director HURD.
- Professor CHAMBERLAIN.
- Professor SPRAGUE.
- Professor HART.
- Professor HASKELL.
- Professor CRAMPTON.
- Professor PHELAN.
- Professor LOCKWOOD.
- Associate Professor E. ANDERSON.
- Associate Professor MACKIMMIE.
- Associate Professor HICKS.
- Secretary WATTS.
- Assistant Professor QUAIFE.
- Assistant Professor MACHMER.
- Assistant Professor A. S. THOMSON.
- Assistant Professor ROBBINS.

UNCLASSIFIED STUDENTS.

Dean LEWIS.
Registrar HASBROUCK.
Professor SEARS.
Professor HASKELL.

APPOINTED TO ATHLETIC BOARD.

Dean LEWIS.
Registrar HASBROUCK.
Associate Professor OSMUN.

APPOINTED TO NONATHLETIC BOARD.

Professor LOCKWOOD.
Assistant Professor MACHMER.

THE COLLEGE.

ADMISSION.

A. Application for Admission.

All correspondence concerning admission should be addressed to the registrar.

Every applicant for admission to the college must be at least sixteen years old, and must present to the registrar proper testimonials of good character. Such testimonials, whenever possible, should come from the principal of the school at which the applicant has prepared for college. Candidates who desire to present themselves for examination in any subjects must make application to the college for such privilege at least one month before examination is desired. Blanks for such application may be obtained by addressing the registrar of the college. All entrance credentials must be in the hands of the registrar before the applicant can matriculate.

B. Modes of Admission.

Students are admitted to the freshman class either upon certificate or upon examination. No *diploma* from a secondary school will be accepted.

Certificates. — Certificates will be received from those schools in New England which have been approved by the New England College Entrance Certificate Board. Principals of schools in New England who desire the certificate privilege should address the secretary of the Board, Professor Frank W. Nicolson, Wesleyan University, Middletown, Conn. Certificates from schools outside of New England may be received if those schools are on the approved list of the leading colleges of the section in which the school in question is located.

The credentials of the Board of Regents of the State of New York are accepted as satisfying the entrance requirements of this college when offered subject for subject.

Certificates in order to be accepted must present at least three of the necessary fourteen credits. It is to be understood, however, that responsibility for certification in either elementary French, elementary German, English 1 or English 2, Latin A, Greek A or algebra must be assumed by one school, if the candidate has received his preparation in any one subject named above in more than one school. Subjects lacking on certificate (except for the permitted number of conditions) must be made up at the time of the examinations for admission.

Blank forms for certification — sent to principals or school superintendents only — may be obtained on application to the registrar of the college.

Examinations. — The examination in each subject may be oral or written, or both. The standard required for passing an examination for admission is 65 per cent. Conditions to the amount of two units will be allowed.

Entrance examination for admission to the Massachusetts Agricultural College will be held at the following centers: —

In June,	Amherst, Department of Physics building. Boston, College of Liberal Arts, Boston University. Worcester, Horticultural Hall.
In September,	Amherst, Department of Physics building.

Please note that September examinations are held in Amherst only.

Schedule for Entrance Examinations, June 22–24, inclusive, 1916. — The examinations in June will follow this schedule: —

First Day.

7.45 A.M.	Registration.[1]
8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.

Second Day.

8.00 A.M.	Required English.
11.00 A.M.	Algebra.
2.00 P.M.	History, required and elective.

Third Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

Schedule for Entrance Examinations in September. — In September, 1916, the examinations will be given September 13 to 16, inclusive, and will follow the order indicated below: —

First Day.

1.00 P.M.	Registration.
1.15–5.00 P.M.	Greek A and B.

Second Day.

8.00 A.M.	Plane geometry.
10.00 A.M.	Chemistry.
11.30 A.M.	Botany.
2.00 P.M.	Solid geometry.
4.00 P.M.	Physics.
5.00 P.M.	Elective English.

Third Day.

8.00 A.M.	Required English.
11.00 A.M.	Algebra, agriculture.
2.00 P.M.	History, required and elective.

Fourth Day.

8.00 A.M.	French, German, required and elective.
1.00 P.M.	Latin A and B and all one-half credit electives, except those already noted.

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[1] Candidates who have no examination at the time set for registration may register at the time of their first examination should they so desire.

C. Requirements for Admission.

The requirements for admission are based on the completion of a four-year high school course, or its equivalent, and are stated in terms of units. The term unit means the equivalent of at least four recitations a week for a school year. **Neither more nor less credit will be given in any subject than is indicated in the table below.** Fourteen units must be offered for admission. In the list given below, *every subject in black-faced type is absolutely required and no substitution is allowed.* The subjects so typed total eight and one-half units. In addition to these points five and one-half more units must be chosen from the subjects printed in light-faced type. Not more than four half-credit units may be offered. No applicant deficient in both algebra and plane geometry will be admitted.

Agriculture,[1]	½ or 1
Botany,[2]	½ or 1
Chemistry,[2]	1
Algebra,	1½
Plane geometry,	1
Solid geometry,	½
Trigonometry,	½
Physics,[2]	1
Geology,	½
Physiography,	½
Physiology,	½
Zoölogy,[2]	½
History[3] (Ancient; Medieval and Modern; English; General; United States and Civics), *any one,*	1[4]
English 1,	1½
English 2,	1½
Modern Language (elementary French or elementary German),	2
Elementary French,[5]	2
Elementary German,[5]	2
Intermediate French,	1
Advanced French,	1
Intermediate German,	1
Advanced German,	1
Greek A,[1]	2
Greek B,[1]	1
Latin A,	2
Latin B,	1
Commercial geography,[6]	½
Drawing,[6]	½
Manual training,[6]	½ or 1

PRESENTATION OF NOTE-BOOKS. — The keeping of a note-book is required as part of the preparation in those subjects indicated (see note 2, below).

Candidates presenting themselves for examination in such subjects must present at the same time the required note-book, properly certified by the principal. Candidates presenting such subjects on certificates should not present note-books; but their certificates must state that note-books have been satisfactorily completed.

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[1] Examination in September only.

[2] Note-book required as part of preparation will be credited as part of the examination.

[3] One must be offered for the required point; one, two or three others may be offered for elective points.

[4] For each offered.

[5] May be offered as elective if not offered to satisfy *required* points.

[6] On certificate only, no examination given.

D. STATEMENT OF PREPARATION REQUIRED FOR ADMISSION.

AGRICULTURE. — Owing to the wide divergence of the methods of teaching agriculture in the public schools, the student will be required to bring a statement from the principal of the amount and kinds of work accomplished and of the text-books used. The examination will be based somewhat upon this information; but it will call for not less than one-half year of creditable work of high school grade. **The examination in agriculture will be given in September only.**

BOTANY. — For one unit of credit in botany, the work outlined in the statement of requirements issued by the College Entrance Examination Board, or its equivalent, will be accepted. This work should occupy one school year and include laboratory and supplementary text-book study. For one-half unit of credit, work that covers the same ground but occupies half the time required for a full unit of credit will be accepted. These requirements are met by such texts as Steven's "Introduction to Botany" and Bergen and Davis's "Principles of Botany." A note-book containing neat, accurate drawings and descriptive records forms part of the requirement for either the half-unit or the one-unit credit, and this note-book must be presented by all applicants for admission upon examination in this subject. The careful preparation of an herbarium is recommended to all prospective students of this college, although the herbarium is not required.

CHEMISTRY. — The entrance examination in chemistry will cover the work outlined by the College Entrance Examination Board as preparatory for college entrance. In general, this consists of a year of high school chemistry from such text-books as Newell's "Descriptive Chemistry" or Remsen's "Elements of Chemistry," with laboratory work on the general properties of the common elements, some of the experiments being quantitative. The keeping of a note-book is required.

MATHEMATICS. — (*a*) *Required.* — Algebra: The four fundamental operations for rational algebraic expressions; factoring, determination of highest common factor and lowest common multiple by factoring; fractions, including complex fractions; ratio and proportion; linear equations, both numerical and literal, containing one or more unknown quantities; problems depending on linear equations; radicals, including the extraction of the square root of polynomials and numbers; exponents, including the fractional and negative; quadratic equations, both numerical and literal; simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations; problems depending upon quadratic equations; the binomial theorem for positive integral exponents, the formulas for the nth term and the sum of the terms of arithmetic and geometric progressions, with applications.

Plane Geometry: The usual theorems and constructions of good text-books, including the general properties of plane rectilinear figures; the circle and the measurement of angles; similar polygons; areas; regular polygons and the measurement of the circle; the solution of numerous original exercises, including loci problems; applications to the mensuration of lines and plane surfaces.

(*b*) *Elective.* — Solid Geometry: The usual theorems and constructions of good text-books, including the relations of planes and lines in space; the properties and measurement of prisms, pyramids, cylinders and cones; the sphere and spherical triangle; the solution of numerous original exercises, including loci problems; applications to the mensuration of surfaces and solids.

Plane Trigonometry: A knowledge of the definitions and relations of trigonometric functions and of circular measurements and angles; proofs of the principal formulas and the application of these formulas to the transformation of the trigonometric functions; solution of trigonometric equations, the theory and use of logarithms, and the solution of right and oblique triangles.

Physics. — To satisfy the entrance requirement in physics, the equivalent of at least one unit of work is required. This work must consist of both class-room work and laboratory practice. The work covered in the class-room should be equal to that outlined in Hall & Bergen's "Text-book of Physics" or Millikan & Gale; the laboratory work should represent at least thirty-five experiments involving careful measurements, with accurate recording of each in laboratory note-book. This note-book, certified by the instructor in the subject, must be submitted by each candidate presenting himself for examination in physics; credit for passing the subject will be given on laboratory notes and on the examination paper submitted. Candidates entering on certificate will not be required to present note-books, but the principal's certification must cover laboratory as well as class-room work.

Physiology. — Hough & Sedgwick's "The Human Mechanism;" Martin's "The Human Body; Briefer Course."

Zoölogy, Physiography, Geology. — The following suggestions are made concerning preparation for admission in the subjects named above: —

For physiography, Davis' "Elementary Physical Geography;" Gilbert & Brigham's "Introduction to Physical Geography." For zoölogy, text-books entitled "Animals" or "Animal Studies," by Jordan, Kellogg and Heath; Linville & Kelley's "A Text-book in General Zoölogy." For geology, A. P. Brigham's "A Text-book of Geology" or Tarr's "Elementary Geology."

Applicants for examination in zoölogy are *required* to present certified laboratory note-books; applicants for examination in the other subjects are *advised* to present note-books, if laboratory work has been done. Good note-books may be given credit for entrance. Examination in these subjects will be general, in recognition of the different methods of conducting courses; but students will be examined on the basis of the most thorough secondary school courses.

History. — The required unit must be offered in either ancient history, medieval and modern history, English history, general history, or United States history and civics. Either one, two or three elective units in any of the historical subjects here named may be offered, provided that no unit be offered in the same subject in which the required unit has been offered.

Preparation in history will be satisfactory if made in accordance with the recommendations of the committee of seven of the American Historical Association, as outlined by the College Entrance Examination Board. The examination will require comparisons and the use of judgment by the candidate rather than the mere use of memory, and it will presuppose the use of good text-books, collateral reading and practice in written work. Geographical knowledge may be tested by requiring the location of places and movements on outline maps.

To indicate in a general way the character of the text-book work expected, the texts of the following authors are suggested: Botsford, Morey or Myers, in ancient history (to 814 A.D.); Adams, West or Myers, in medieval history; Montgomery, Larned or Cheyney, in English history; Myers or Fisher, in general history; Fiske, together with MacLaughlin or Montgomery, in United States history and civics.

English. — For 1916–19 inclusive: —

The study of English in school has two main objects: (1) command of correct and clear English, spoken and written; (2) ability to read with accuracy, intelligence and appreciation.

(1) *Grammar and Composition* (One and One-half Units). — The first object requires instruction in grammar and composition. English grammar should ordinarily be reviewed in the secondary school; and correct spelling and grammatical accuracy should be rigorously exacted in connection with all written work during the four years. The principles of English composition governing punctuation, the use of words, sentences and paragraphs should be thoroughly mastered; and practice in composition, oral as well as written, should extend throughout the secondary school period. Written exercises may well comprise letter-writing, narration, description and easy exposition and argument. It is advisable that subjects for this work be taken from the student's personal experience, general knowledge and studies other than English, as well as from his reading in literature. Finally, special instruction in language and composition should be accompanied by concerted effort of teachers in all branches to cultivate in the student the habit of using good English in his recitations and various exercises, whether oral or written.

(2) *Literature.* — The second object is sought by means of two lists of books, headed, respectively, "Reading" and "Study," from which may be framed a progressive course in literature covering four years. In connection with both lists the student should be trained in reading aloud and encouraged to commit to memory some of the more notable passages both in verse and in prose. As an aid to literary appreciation, he is further advised to acquaint himself with the most important facts in the lives of the authors whose works he reads and with their place in literary history.

A. Reading (One and One-half Units). — The aim of this course is to foster in the student the habit of intelligent reading and to develop a taste for good literature by giving him a first-hand knowledge of some of its best specimens. He should read the books carefully, but his attention should not be so fixed upon details that he fails to appreciate the main purpose and charm of what he reads.

With a view to large freedom of choice, the books provided for reading are arranged in the following groups, from each of which at least two selections are to be made, except as otherwise provided under Group I.: —

Group I. Classics in Translation: The "Old Testament," comprising at least the chief narrative episodes in Genesis, Exodus, Joshua, Judges, Samuel, Kings and Daniel, together with the books of Ruth and Esther; the "Odyssey," with the omission, if desired, of Books I., II., III., IV., V., XV., XVI., XVII.; the "Iliad," with the omission, if desired, of Books XI., XIII., XIV., XV., XVIII., XXI.; the "Æneid." The "Odyssey," "Iliad" and "Æneid" should be read in English translations of recognized literary excellence.

For any selection from Group I. a selection from any other group may be substituted.

Group II. Shakspere: "Midsummer Night's Dream;" "Merchant of Venice;" "As You Like It;" "Twelfth Night;" "The Tempest;" "Romeo and Juliet;" "King John;" "Richard II.;" "Richard III.;" "Henry V.;" "Coriolanus;" "Julius Cæsar;"[1] "Macbeth;"[1] "Hamlet."[1]

Group III. Prose Fiction: Malory's "Morte d'Arthur" (about 100 pages); Bunyan's "Pilgrim's Progress," Part I.; Swift's "Gulliver's Travels" (voyages to Lilliput and to Brobdingnag); Defoe's "Robinson Crusoe," Part I.; Goldsmith's "Vicar of Wakefield;" Frances Burney's "Evelina;" Scott's novels, any *one;* Jane Austen's novels, any *one;* Maria Edgeworth's "Castle Rackrent" or "The Absentee;" Dickens' novels, any *one;* Thackeray's novels, any *one;* George Eliot's novels, any *one;* Mrs Gaskell's "Cranford;" Kingsley's "Westward Ho!" or "Hereward the Wake;" Reade's "The Cloister and the Hearth;" Blackmore's "Lorna Doone;" Hughes's "Tom Brown's School Days;" Stevenson's "Treasure Island" or "Kidnapped" or "Master of Ballantrae;" Cooper's novels, any *one;* Poe's "Selected Tales;" Hawthorne's "The House of the Seven Gables" or "Twice Told Tales" or "Mosses from an Old Manse;" a collection of short stories by various standard writers.

Group IV. Essays, Biography, etc.: Addison and Steele's "The Sir Roger de Coverley Papers" or selections from the "Tatler" and "Spectator" (about 200 pages); selections from Boswell's "Life of Johnson" (about 200 pages); Franklin's "Autobiography;" selections from Irving's "Sketch Book" (about 200 pages) or "Life of Goldsmith;" Southey's "Life of Nelson;" selections from Lamb's "Essays of Elia" (about 100 pages); selections from Lockhart's "Life of Scott" (about 200 pages); Thackeray's "Lectures on Swift, Addison and Steele in the English Humorists;" Macaulay: any one of the following essays: "Lord Clive," "Warren Hastings," "Milton," "Addison," "Goldsmith," "Frederic the Great," "Madame d'Arblay;" selections from Trevelyan's "Life of Macaulay" (about 200 pages); Ruskin's "Sesame and Lilies" or "Selections" (about 150 pages); Dana's "Two Years before the Mast;" Lincoln's "Selections," including at least the two inaugurals, the speeches in Independence Hall and at Gettysburg, the last public address, the letter to Horace Greeley, together with a brief memoir or estimate of Lincoln; Parkman's "The Oregon Trail;" Thoreau's "Walden;" Lowell's "Selected Essays" (about 150 pages); Holmes's "The Autocrat of the Breakfast Table;" Stevenson's "An Inland Voyage" and "Travels with a Donkey;" Huxley's "Autobiography" and selections from "Lay Sermons," including the addresses on "Improving Natural Knowledge," "A Liberal Education" and "A Piece of Chalk;" a collection of "Essays" by Bacon, Lamb, De Quincey, Hazlitt, Emerson and later writers; a collection of "Letters" by various standard writers.

Group V. Poetry: Palgrave's "Golden Treasury" (first series), Books II. and III., with special attention to Dryden, Collins, Gray, Cowper and Burns; Palgrave's "Golden Treasury" (first series), Book IV., with special attention to Wordsworth, Keats and Shelley (if not chosen for study under B); Goldsmith's "The Traveller" and "The Deserted Village;" Pope's "The Rape of the Lock;" a collection of English and Scottish ballads, as, for example, some "Robin Hood" ballads, "The Battle of Otterburn," "King Estmere," "Young Beichan," "Bewick and Grahame," "Sir Patrick Spens" and a selection from later ballads; Coleridge's "The Ancient Mariner," "Christabel" and "Kubla Khan;" Byron's "Childe Harold," Canto III. or IV., and "The Prisoner of Chillon;" Scott's "The Lady of the Lake" or "Marmion;" Macaulay's "The Lays of Ancient Rome," "The Battle of Naseby," "The

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[1] If not chosen for study under B.

Armada," "Ivry;" Tennyson's "The Princess" or "Gareth and Lynette," "Lancelot and Elaine" and "The Passing of Arthur;" Browning's "Cavalier Tunes," "The Lost Leader," "How They Brought the Good News from Ghent to Aix," "Home Thoughts from Abroad," "Home Thoughts from the Sea," "Incident of the French Camp," "Hervé Riel," "Pheidippides," "My Last Duchess," "Up at a Villa — Down in the City," "The Italian in England," "The Patriot," "The Pied Piper," "De Gustibus," "Instans Tyrannus;" Arnold's "Sohrab and Rustum" and "The Forsaken Merman;" selections from American poetry, with special attention to Poe, Lowell, Longfellow and Whittier.

B. Study. — This part of the requirement is intended as a natural and logical continuation of the student's earlier reading, with greater stress laid upon form and style, the exact meaning of words and phrases, and the understanding of allusions. The books provided for study are arranged in four groups, from each of which one selection is to be made.

Group I. Drama: Shakspere's "Julius Cæsar," "Macbeth," "Hamlet."

Group II. Poetry: Milton's "L'Allegro," "Il Penseroso" and either "Comus" or "Lycidas;" Tennyson's "The Coming of Arthur," "The Holy Grail" and "The Passing of Arthur;" the selections from Wordsworth, Keats and Shelley in Book IV. of Palgrave's "Golden Treasury" (first series).

Group III. Oratory: Burke's "Speech on Conciliation with America;" Macaulay's "Speech on Copyright" and Lincoln's "Speech at Cooper Union;" Washington's "Farewell Address" and Webster's "First Bunker Hill Oration."

Group IV. Essays: Carlyle's "Essay on Burns," with a selection from Burns's "Poems;" Macaulay's "Life of Johnson;" Emerson's "Essay on Manners."

Examination. — However accurate in subject-matter, no paper will be considered satisfactory if seriously defective in punctuation, spelling or other essentials of good usage.

The examination will be divided into two parts, one of which will be on grammar and composition, and the other on literature.

In grammar and composition, the candidate may be asked specific questions upon the practical essentials of these studies, such as the relation of the various parts of a sentence to one another, the construction of individual words in a sentence of reasonable difficulty, and those good usages of modern English which one should know in distinction from current errors. The main test in composition will consist of one or more essays, developing a theme through several paragraphs; the subjects will be drawn from the books read, from the candidate's other studies and from his personal knowledge and experience quite apart from reading. For this purpose the examiner will provide several subjects, perhaps eight or ten, from which the candidate may make his own selections. He will not be expected to write more than four hundred words per hour.

The examination in literature will include: —

(*a*) General questions designed to test such a knowledge and appreciation of literature as may be gained by fulfilling the requirements defined under "A, Reading," above. The candidate will be required to submit a list of the books read in preparation for the examination, certified by the principal of the school in which he was prepared; but this list will not be made the basis of detailed questions.

(*b*) A test on the books prescribed for study, which will consist of questions upon their content, form and structure, and upon the meaning of such words, phrases and allusions as may be necessary to an understanding of the works and an appreciation of their salient qualities of style. General questions may also be asked concerning the lives of the authors, their works and the periods of literary history to which they belong.

English, Elective. — To secure a fourth entrance credit in English the applicant must have done, in addition to the requirements stated above, work equivalent to a course meeting at least four times a week for one year. Applicants not certified with this fourth entrance credit will be examined in September, provided that they notify the Department of English of their desire on or before June 1. **(The examination in English elective will be given in September only. After September, 1916, the maximum credits accepted in English, either by certificate or by examination, will be three.)**

Subjects accepted. — Applicants may offer (*a*) any one of the subjects stated hereunder, or (*b*) any two of these subjects in combination.

(*a*) History of American literature.
(*b*) History of English literature.
(*c*) Classics *other than those read to meet the three-credit requirement.*
(*d*) Advanced composition.
(*e*) History of the English language.
(*f*) Advanced high school grammar.

French. — Elementary: The necessary preparation for this examination is stated in the description of the two-year course in elementary French recommended by the Modern Language Association, contained in the definition of requirements of the College Entrance Examination Board.

Third and fourth year French (elective subjects for admission). — For a third credit unit in French as an elective subject for entrance, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in French will be given unless the candidate has presented elementary French on certificate, or has written the examination in elementary French.

No examination for a fourth credit in French will be given unless the candidate has presented both elementary and intermediate French upon certificate, or has written the examination in both elementary and intermediate French.

German. — Elementary: The entrance requirements in German conform to those of the College Entrance Examination Board for elementary German (the standard two-year requirements).

Third and fourth year German (elective subjects for admission). — For a third credit unit in German as an elective subject for entrance, when required units have been offered in German, the work heretofore described by the College Entrance Examination Board as "intermediate" is expected. For a fourth credit unit, the work described as "advanced" is expected.

No examination for a third unit in German will be given unless the candidate has presented elementary German upon certificate, or has written the examination in elementary German.

No examination for a fourth credit in German will be given unless the candidate has presented both elementary and intermediate German upon certificate, or has written the examination for both elementary and intermediate German.

Greek. — Greek will receive credit as an elective requirement upon either examination or certification, as follows. (**The examination in Greek A and Greek B will be given in September only.**)

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from the first four books of Xenophon's "Anabasis," and (*b*) the translation of passages of Attic prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages from the first six books of Homer's "Iliad," and (*b*) translation of passages of Homer's "Iliad" at sight, with questions on the form and constructions of the passages.

Latin. — Latin will receive credit as an elective requirement upon either examination or certification, as follows: —

A. Two credit units will be allowed if satisfactory proficiency is shown (including grammar) in (*a*) the translation of a passage or passages taken from Cæsar's "Gallic War," covering at least four books, and (*b*) the translation of passages of Latin prose at sight.

B. A third credit unit will be allowed if, in addition to the above, satisfactory proficiency be shown in (*a*) the translation of a passage or passages selected from either Books I. to VI. of Virgil's "Æneid," or six orations of Cicero, including those against Catiline; and (*b*) the translation into Latin prose of a passage of connected English narrative based on some portion of Cæsar's "Gallic War," Books I. to IV.

Commercial Geography.[1] — Preparation should be made in a course equivalent to that laid down in Adams' "Commercial Geography," Trotter's "Geography of Commerce," or a similar work. (No examination given.)

Drawing.[1] — The applicant may offer either freehand or mechanical drawing or both. He must be able to make an accurate freehand sketch, in either outline or light and shade, of the appearance of a group of geometric solids, and have a sufficient knowledge of perspective to enable him to draw correctly a simple geometric model from memory; or, if he present mechanical drawing, he must have working familiarity with drawing instruments, and be able to make an accurate inked working drawing, in orthographic projection, of some simple object. Emphasis is laid on facility in doing good freehand lettering. For a limitation of the work that may be presented, see "Manual Training." (No examination given.)

Manual Training.[1] — An entrance credit of one-half or one unit is allowed for manual training, on the presentation of a certificate from the principal of the school showing the scope and character of the applicant's work. The preparation may include mechanical drawing, working in wood, metals, leather, etc. When mechanical drawing is presented as a part of the work in manual training, no other credit for drawing will be allowed. No examination is given in this subject; applicants must present certificates to secure credit.

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[1] **On certificate only; no examination given.**

E. ADMISSION TO ADVANCED STANDING.

Candidates for admission to advanced standing, in addition to meeting the regular entrance requirements, must also pass examinations in those subjects already pursued by the class they desire to enter. To meet this requirement, a student transferring to this college from another college or university of recognized standing must present the following credentials: —

1. A letter of honorable dismissal from the institution with which he has been connected.
2. A statement or certificate of his entrance record.
3. A statement from the proper officer showing a complete record of his work while in attendance.
4. A marked catalogue showing the courses pursued.

These credentials should be presented to the registrar. Applications will be judged wholly on their merits and the college may prescribe additional tests before accepting applicants or determining the standing to be granted them.

F. OTHER INFORMATION ABOUT ENTRANCE.

1. The privileges of the college may be withdrawn from any student at any time if such action is deemed advisable. (It is immaterial whether the pupil has entered by certificate or by examination.)
2. The examination in each subject may be either oral or written, or both. The standard required for passing an entrance examination is 65 per cent.
3. Candidates must receive credit for twelve units out of the total number required for entrance, and will be conditioned in those subjects not passed. Not more than five and one-half credits from the elective group will be accepted. No candidate deficient in both algebra and plane geometry will be admitted.
4. Examinations for the removal of entrance conditions will be held as follows: (1) First entrance condition examination, in the week following the Thanksgiving recess. (2) Second entrance condition examination, in the sixteenth week of the first semester.
5. Credits for entrance requirements, whether gained by certificate or by examination, will hold good for one year.
6. Examinations in part of the subjects required for entrance may be taken one year before entering college.
7. For information concerning expenses, scholarships, etc., see "General Information."
8. For information concerning admission to short courses see "Short Courses."

G. UNCLASSIFIED STUDENTS.

All requests for information concerning admission of unclassified students should be addressed to Dean Edward M. Lewis, chairman of committee on unclassified students.

Students not candidates for a degree (unclassified students) are admitted under the following provisions: —

1. No entrance examination is required, but applicants must bring certificates showing that they have finished a four-year high school course or its equivalent, and furnish satisfactory testimonials as to moral character.

2. No applicant under twenty-one years of age will be admitted as an unclassified student.

3. Each unclassified student must take from the regular courses a minimum of twelve credit hours a week.

4. In order to be admitted to any course, an unclassified student must have had all prerequisite subjects for that course.

5. Every unclassified student must do all the work of the courses elected, and take all examinations therein. In order to pass such courses he must attain a grade of at least 75 per cent. An unclassified student who passes in less than two-thirds of his work will be dropped from college.

6. All unclassified students are subject to the supervision of a special committee.

7. Any unclassified student may be dropped from college at any time if his presence in any class is undesirable or his work is unsatisfactory; and no unclassified student will be allowed to remain in college more than four semesters without the special permission of the faculty.

8. Unclassified students are subject to the regulations applying to classified students.

9. No student of this or any other institution who has not done efficient work therein shall be permitted to register as an unclassified student.

10. No unclassified student shall be allowed to participate in any intercollegiate contests.

COURSES OF INSTRUCTION.

A. TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

The figures indicate the number of credit hours a week. For details, see the descriptions of courses.

FRESHMAN YEAR.

First Semester.

All work required.

Subjects.	Hours per Week.
Chemistry,	3
Algebra,	3
Solid geometry,[1]	2
English,	4
Public speaking (at option of instructor),	1
French or German,[2]	4
Drill,	1
Hygiene,	1
College life (attendance without credit).	
	18 or 19

Second Semester.

All work required.

Subjects.	Hours per Week.
Animal husbandry,	2
Chemistry,	3
Trigonometry,	3
Algebra,	2
English,	4
Public speaking (if not taken in semester one),	1
French or German,	4
Drill,	1
Physical education,	1
	20 or 21

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[1] To be taken in course when not offered for entrance.

[2] Students who have had three or four years of one language in the preparatory school will elect the other language. Students who have had two years of one language may have their choice of election. Whichever language they so elect must be continued to the end of the first semester of the sophomore year. Eleven college credits are required in this language.

SOPHOMORE YEAR.

First Semester.

All work required except chemistry or animal husbandry.

Subjects.	Hours per Week.
Agronomy,	3
Physics,	5
Zoölogy,	3
English,	2
French or German,	3
Tactics,	1
Drill,	1
	18
[Chemistry or animal husbandry (may be elected subject to approval by the dean),	3]
	[21]

Second Semester.[1]

Required.

Subjects.	Hours per Week.
Elementary horticulture,	2
Botany,	4
English,	2
Agricultural industry,	3
Drill,	1
Tactics,	1
Physical education,	1
	14

Elective.

Subjects.		Hours per Week.
French or German, Geology, Physics, Chemistry, Surveying,	Each 3 hours. Any two,	6
		20

The following table shows the course of study which it is intended will be in effect with the entrance of the class of 1920: —

FRESHMAN YEAR.

First Semester.		*Second Semester.*	
English and public speaking,	4 or 3	English and public speaking,	4 or 3
Algebra,	3	Trigonometry,	3
Geometry,	2	Algebra,	2
Chemistry,	3	Chemistry,	3
Drill, etc., 2; military tactics, 1,	3	Drill, etc., 2; military tactics, 1,	3
Language,	3	Agricultural geology,	3
Agriculture and horticulture,	2	Language,	3
	20 or 19	Agriculture and horticulture,	2
			23 or 22

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[1] All courses under "Required," with any two of those under "Elective."

Sophomore Year.

First Semester.		*Second Semester.*	
Physics,	4	Agronomy,	3
English,	2	English,	2
Zoölogy,	3	Botany,	4
Rural community,	2	Drill, etc.,	2
Drill, etc.,	2	Agricultural industry,	3
2 or 3 electives,	6 or 9	2 or 3 electives,	6 or 9
	19 to 22		20 to 23

Electives (subject to Revision).		*Electives (subject to Revision).*	
Language,	3	Language,	3
Mathematics,	3	Agriculture (?),	3
Agriculture,	3	Chemistry,	3
Chemistry,	3	Entomology,	4
Free-hand drawing,	3	Geology,	3
Anthropology,	3	Surveying,	3
		Horticulture,	3
		Physics,	4
		Zoölogy,	3
		Agricultural education (?),	3
		Mechanical drawing,	3

Four Term Plan.

The faculty and the trustees have approved a plan whereby, beginning September, 1916, the college year will be divided into four terms, including a summer session. It is expected that by offering work in the practical departments during the summer months a more adequate training will be assured to the students. The plan contemplates no marked changes in the content or character of the various courses of study described in this catalogue. The adaptation of these courses to the new division of the year is now being made, and a detailed statement relative to the readjustment will be published in April or May, 1916. A copy of this bulletin may be had on application.

B. MAJORS: JUNIOR AND SENIOR YEARS.

General Statement.

A major consists of 30 hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules governing Majors.

Rule 1. *Election.* — Each student, in the second semester of his sophomore year, shall elect a major subject from the list of majors given below; and this major shall consist of 30 credit hours of correlated work.

Rule 2. *Minimum Credits.* —The minimum number of credits for the junior and senior years shall be 65, inclusive of military drill and physical education.

Rule 3. *Maximum Credits.* — The maximum number of credits for any semester of the junior or senior year shall be 21.

Rule 4. *Humanities and Rural Social Science.* — A minimum of 12 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 3 credit hours will be required in each of the divisions.

Rule 5. *Advisers.* — The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 30 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.* — Each student is required to take 30 hours in his major and also 12 hours in the Divisions of the Humanities and Rural Social Science, making a total of 42 hours. He is allowed free choice of courses to complete his required hours, this remainder amounting to 17 hours minimum, or 37 hours maximum for the two years.

Rule 7. *Registration.* — No upper classman shall register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office on June 1.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the year and countersign the card.

(3) Each course card must be filled out, giving the name of student, his college address, the name of parent or guardian, and the student's home address. When the major courses have been entered on this card, and the hours of free elections added by the student, the card must be returned to the registrar not later than June 10.

RULE 8. *Changes.* — Applications for changes may be made to the dean in writing at any time; when approved by him and by the committee on scholarship, they become operative at the beginning of the semester following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

LIST OF MAJORS IN THE DIVISION OF AGRICULTURE.

Agriculture.

Professor JAMES A. FOORD, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 6,	3
Animal Husbandry 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Dairying 1,	3
Dairying 2,	3
Farm Administration 3,	3
Farm Administration 4,	3
Microbiology 1 and 2,	5
	32

Chemistry 7 and 8, Veterinary Science 1, Microbiology 2, Pomology 1 and Animal Husbandry 6 are suggested as additional courses for the student fitting himself for general agriculture.

Agronomy.

Professor SIDNEY B. HASKELL, Adviser.

Course.	Credit.
Agronomy 3,	3
Agronomy 4,	3
Agronomy 5,	3
Agronomy 6,	3
Agronomy 8,	3
Animal Husbandry 9,	3
Farm Administration 4,	3
Chemistry 5,	5
Chemistry 6,	5
	31

Animal Husbandry.

Professor JOHN C. MCNUTT, Adviser.

Course.	Credit.
Agronomy 3,	3
Veterinary Science 1, veterinary hygiene and stable sanitation,	3
Veterinary Science 2, general veterinary pathology (materia medica and therapeutics),	3
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 10,	3
Animal Husbandry 11,	2
Dairying 1,	3
Farm Administration 3,	3
Farm Administration 4,	3
	32

Dairying.

Professor William P. B. Lockwood, Adviser.

Course.	Credit.
Animal Husbandry 5,	3
Animal Husbandry 6,	1
Animal Husbandry 8,	2
Animal Husbandry 9,	3
Animal Husbandry 11,	2
Dairying 1,	3
Dairying 2,	3
Dairying 3,	3
Microbiology 11 and 12,	3
Farm Administration 3,	3
Farm Administration 4,	3
	29

Poultry Husbandry.

Professor John C. Graham, Adviser.

Course.	Credit.
Poultry Husbandry 1,	2
Poultry Husbandry 2,	2
Poultry Husbandry 3,	1
Poultry Husbandry 4,	1–3
Poultry Husbandry 5,	1
Poultry Husbandry 6,	3
Poultry Husbandry 7,	3
Poultry Husbandry 9,	3
Pomology 1,	3
Agronomy 3,	3
Animal Husbandry 5,	3
Animal Husbandry 9,	3
Veterinary Science 7,	3
	31–33

LIST OF MAJORS IN THE DIVISION OF HORTICULTURE.

Floriculture.

Associate Professor Arno H. Nehrling, Adviser.

Course.	Credit.
Floriculture 1,	4
Floriculture 2,	4
Floriculture 3,	3
Floriculture 4,	3
Horticulture 3,	3
Horticulture 4,	3
Entomology 1,	3
Market Gardening 2,	3
Botany 2,	4
	30

Note. — Horticulture 3 and 4 is a junior subject, but to balance the work for the two years it would be better for the floricultural students to take the course in the senior year.

Forestry.

Professor William D. Clark, Adviser.

Course.	Credit.
Forestry 3,	3
Forestry 4,	3
Forestry 5,	5
Forestry 6,	3
Entomology 5,	3
Landscape Gardening 1,	3
Horticulture 3,	3
Horticulture 4,	3
Botany 13,	4
	30

Students who propose to major in forestry should elect geology and surveying in sophomore year.

Landscape Gardening.

Professor Frank A. Waugh, Adviser.

Course.	Credit.
Landscape Gardening 1,	3
Landscape Gardening 2,	3
Landscape Gardening 3,	3
Landscape Gardening 4,	3
Landscape Gardening 5,	2
Landscape Gardening 6 or 10,	2
Landscape Gardening 7,	3
Landscape Gardening 8,	3
Drawing 1,	3
Drawing 2,	3
Horticulture 3,	3
	31

Courses for juniors *only:* Landscape Gardening 1 and 2, Drawing 1 and 2.

Courses for seniors and graduates *only:* Landscape Gardening 3, 4, 7 and 8.

Courses open to juniors and seniors, both if possible: Horticulture 3 and 4.

This grouping of subjects is offered only as an example. Other groupings may be approved by the adviser, but such other groupings must be subject to the class schedule.

Pomology.

Professor Fred C. Sears, Adviser.

Course.	Credit.
Pomology 1,	3
Pomology 2,	3
Pomology 3,	3
Pomology 4,	3
Pomology 5,	3
Pomology 6,	2
Botany 5,	2
Agronomy 5,	3
Entomology 1,	3
Entomology 2,	3
	28

MAJOR IN THE DIVISION OF THE HUMANITIES.

Rural Journalism.

Associate Professor Robert W. Neal, Adviser.

	Credit.
Rural Journalism 1,	3
Rural Journalism 2,	3
Rural Journalism 3,	2
Rural Journalism 4,	2
Rural Journalism 5,	1
Rural Journalism 7,	2
Rural Journalism 8,	2
Rural Journalism 9,	3
Rural Journalism 10,	3
Economics and Sociology 1,	3
Agricultural Economics 5,	3
Rural Sociology 1,	3
	30

LIST OF MAJORS IN THE DIVISION OF RURAL SOCIAL SCIENCE.

Agricultural Education.

Professor William R. Hart, Adviser.

Course.	Credit.
Agricultural Education 1,	3
Agricultural Education 2,	3
Agricultural Education 3,	3
Agricultural Education 4,	3
Agronomy 3,	3
Dairying 5,	2
Farm Administration 3,	3
Poultry Husbandry 1,	2
Market Gardening 2, Agronomy 5,	3
Botany 5,	2
Pomology 1,	3
	30

Some substitutions of other technical courses for some of the technical courses above mentioned will be made to meet the needs of individual students.

Rural Social Science.

Professor John Phelan, Adviser.

Course.	Credit.
Economics and Sociology 1,	3
Economics and Sociology 8,	3
History and Government 3,	3
Agricultural Economics 3,	3
Agricultural Economics 5,	3
Agricultural Economics 7 or 8,	3
Rural Sociology 2,	3
Rural Sociology 5,	3
Rural Sociology 10,	3
Rural Sociology 8,	3
Agricultural Education 1 or 5,	3
	33

The major will consist of 30 hours selected from this list.

LIST OF MAJORS IN THE DIVISION OF SCIENCE.

Agricultural Chemistry.

Associate Professor Charles A. Peters, Adviser.

Course.	Credit.
Chemistry 5,	5
Chemistry 6,	5
Chemistry 9,	5
Chemistry 10,	5
Chemistry 11,	5
Chemistry 12, 14 or 16,	5
Chemistry 13,	3
Chemistry 15,	3
Chemistry 18,	2
	38

The major will consist of 30 credit hours selected from this list. The student will be advised concerning other subjects suitable to be taken in connection with chemistry.

Economic Entomology.

Professor Henry T. Fernald, Adviser.

Course.	Credit.
Entomology 1,	3
Entomology 2,	2
Entomology 3,	4
Entomology 4,	4
Entomology 5,	3
Entomology 8,	3
Entomology 11,	2
Botany 5,	3
Zoölogy 3,	3
Zoölogy 4,	3
	32

A major in economic entomology does not necessarily include all the subjects given in this list, but may be varied to some extent, in accordance with the future plans of the student, other modifications being permissible.

Microbiology.

Professor Chas. E. Marshall, Adviser.

Course.	Credit.
Microbiology 1 or 2,	5
Microbiology 3 or 4,	5
Microbiology 5 or 6,	3
Microbiology 7 or 8,	3
Chemistry 3,	5
Chemistry 4,	5
Chemistry 5,	3
Chemistry 6,	3
	32

Courses 9 in chemistry; 3, 4, 5 in botany; 3, 4, 5, 6 in zoölogy; 1, 3, 5, 6 in veterinary science, together with German and French, are suggested as collateral lines. Dairying 1 and Agronomy 5 are essential to a grasp of the larger problems involved in microbiology as applied to agriculture.

Plant Physiology and Pathology.

Professor George E. Stone,[1] Adviser.

Course.	Credit.
Botany 3,	4
Botany 4,	3
Botany 9,	4 or 5
Botany 10,	4 or 5
Botany 11,	4
Botany 12,	4
Chemistry 5,	5
Chemistry 6,	5
	33 or 35

SUMMARY.

There are four preliminary steps which a student should take in arranging for his major work.

1. Select a major.

2. Confer with major adviser for arrangement of courses, the plan to be approved by adviser in accordance with Rule 5 previously stated.

3. Select courses covering the four semesters of the junior and senior years in such a way that a minimum of 12 credits will be taken in the two divisions, the Humanities and Rural Social Science; the distribution of all but 3 of these credits may be decided by the student.

4. Choose other courses so that the total number of credits for any semester shall be not less than 16 nor more than 21. (See Rules 2 and 3.)

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[1] On leave of absence; Associate Professor Osmun acting as head of Department of Botany.

C. UNDERGRADUATE COURSES.

All courses given in the *first semester bear odd numbers;* all given in the *second semester bear even numbers.* Studies are pursued in courses, "course" implying the study given a subject within one semester, without regard to the total number of hours or to the number of credits. The special mention of certain courses as prerequisite to other courses does not imply that no courses but those so mentioned are "preliminary or preparatory" within the meaning of the Book of Rules.

DIVISION OF AGRICULTURE.

Professor FOORD.

AGRONOMY.

Professor HASKELL, Assistant Professor JONES, Mr. MERKLE, Mr. COBB.

1. SOILS AND FERTILIZERS. — A study of soils and their properties, soil management, methods of soil improvement and maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments. Prerequisites, Chemistry 1 and 2. Sophomores; 2 lecture periods and 1 laboratory period weekly. Credit, 3. Professor HASKELL and Assistants.

3. FIELD AND FORAGE CROPS. — History, classification and production of maize and of those grasses, legumes, forage and root crops suited to New England conditions. The work includes lecture, laboratory and field study of these various crops. Prerequisites, Agronomy 1 and Botany 2. Primarily for juniors; 1 lecture and 2 laboratory periods. Credit, 3.
Assistant Professor JONES and Mr. COBB.

4. ADVANCED FIELD CROPS. — A study of the cereal grains, with lectures, laboratory and field study of the purity, quality and vitality of the seeds of farm crops and the handling, grading and judging of their products. Prerequisite, Agronomy 3. Primarily for juniors; 2 lectures and 1 laboratory period. Credit, 3. Assistant Professor JONES and Mr. COBB.

5. ADVANCED SOILS. — A field, lecture and laboratory course on soils and their adaptability to different uses. The field work consists of a detailed soil survey of the college farm and other areas, followed by a laboratory study of the physical properties of soils collected. Prerequisite, Agronomy 1. Primarily for seniors; 1 lecture period and 1 4-hour laboratory period weekly. Credit, 3.
Professor HASKELL and Mr. MERKLE.

6. DRAINAGE AND IRRIGATION. — A field and lecture course on soil improvement by drainage and irrigation, with special reference to problems of this nature as faced by Massachusetts farmers. Prerequisites, Agronomy 1 and Mathematics 6. One lecture period and 1 4-hour laboratory period weekly. Credit, 3. Professor HASKELL and Mr. MERKLE.

8. MANURES AND FERTILIZERS. — An advanced course, giving a general discussion of the different theories which have been held relative to the func-

tions and importance of manures and fertilizers, and leading up to the views at present accepted. Considerable attention is devoted to consideration of the experimental work which has been done, and which is now in progress, on manures and fertilizers. For seniors only. Prerequisite, Agronomy 1. Three lectures weekly. Credit, 3. Professor HASKELL.

10. BREEDING OF FIELD CROPS. — This course deals with the improvement, by selection and breeding, of the crops studied in Courses 3 and 4. Prerequisite, Agronomy 4. Seniors only; 2 lecture periods weekly. Credit, 2.
Assistant Professor JONES.

ANIMAL HUSBANDRY.

Professor McNUTT,[1] Assistant Professor QUAIFE, Mr. WIGHT, Mr. FISH.

Required Course.

2. MARKET CLASSES AND GRADES OF LIVE STOCK. — A study of the different market classes and grades of horses, cattle, sheep and swine. The purpose of this course is to familiarize beginners with the different classes of stock, and to give them a grounding in live stock judging. Text-book, Craig's "Live Stock Judging." Freshmen; 2 laboratory periods. Credit, 2.
Professor McNUTT and Assistant Professor QUAIFE.

Elective Courses.

3. BREEDS AND TYPES OF LIVE STOCK. — A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Text-book, Plumb's "Breeds and Types of Farm Animals." Prerequisite, Animal Husbandry 2. Sophomores; 2 lectures and 2 laboratory periods. Credit, 4. Assistant Professor QUAIFE.

5. PRINCIPLES OF BREEDING. — This course is designed to familiarize the student with the problems involved in animal and plant improvement; to acquaint him with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; De Vrie's theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types; the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in live stock improvement. Text, "Genetics," by Herbert E. Walter. Supplementary reading. Prerequisite, Zoölogy 1. Three lectures. Credit, 3. Mr. WIGHT.

6. LIVE STOCK MANAGEMENT. — The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, breaking to drive, driving, harnessing, casting and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work. Prerequisite, Animal Husbandry 3. Juniors; 1 laboratory period. Credit, 1.
Assistant Professor QUAIFE.

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[1] Appointment in effect Jan. 1, 1916. Vice-Associate Professor J. A. McLean resigned Sept. 1, 1915.

8. Advanced Stock Judging. — This course is designed to equip animal husbandry students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected largely from this class. Must be preceded by or accompany Animal Husbandry 6. Juniors; 2 laboratory periods. Credit, 2.

Professor McNutt.

9. Feeding and Management. — A study of the principles of animal nutrition; of the composition and qualities of feeding materials; of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production. Text-book, Henry's "Feeds and Feeding." Prerequisite, Chemistry 5 or 7. Seniors; 3 lectures. Credit, 3.

Assistant Professor Quaife.

10. Feeding and Management. — A continuation of Course 9, dealing in a similar manner with horses, sheep, beef cattle and swine. Prerequisite, Course 9. Seniors; 3 lectures. Credit, 3. Assistant Professor Quaife.

11. Herd and Stud-book Study. — An advanced course in the study of the breeds of live stock, familiarizing the student with the detailed history of the breed, the most productive sires and dams of the various breeds, and the successful lines and methods of breeding. Prerequisites, Animal Husbandry 5 and 8. Seniors; 2 hours. Credit, 3. Professor McNutt [?]

12. Seminar. — Advanced study upon questions pertaining to live stock and live stock production. Each student electing this work will choose some particular line of work in which he is specially interested, and will pursue study in this subject by reading, compilation and research. There will be no regular lecture period, but seminars will be held. A satisfactory report of the results must be presented in a thesis. Open only to seniors majoring in animal husbandry. Credit, 1. Professor McNutt.

DAIRYING.

Professor Lockwood, Assistant Professor Jamison, Mr. Coons, Mr. Baldinger.

Elective Courses.

1. Milk and Milk Composition. — The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, test for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems. Two lecture hours and 1 2-hour laboratory period. Credit, 3.

Assistant Professor Jamison and Chemistry Department.

2. Buttermaking. — A study of separators and cream separation; handling milk and cream for buttermaking; preparation of starters, and ripening

cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof. Prerequisite, Course 1. One lecture hour and 2 2-hour laboratory periods. Credit, 3. Professor Lockwood, Assistant Professor Jamison, Mr. Coons.

3. Milk Products. — The manufacture of milk products other than butter, including cheddar cheese, soft and fancy cheese, ice cream, condensed milk, casein, milk powder, etc. Laboratories, largely the making of soft and fancy cheese and ice cream. Prerequisite, Dairying 1. Two lecture hours and 1 2-hour laboratory period. Credit, 3. Mr. Baldinger.

4. Market Milk. — A study of market milk conditions; extent and development of the business; supply and delivery; food value of milk and its uses as food; milk and its relation to the public health; proper methods for handling milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection. Prerequisite, Dairying 1. Two lecture hours and 1 2-hour laboratory period. Credit, 3.
Professor Lockwood, Assistant Professor Jamison.

6. Dairying. — A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary buttermaking; proper methods of handling milk and cream; and the relation of market milk to the public health. One lecture hour and 2 2-hour laboratory periods. Credit, 3.
Assistant Professor Jamison and Mr. Baldinger.

FARM ADMINISTRATION.

Professor Foord, Mr. Peacock.

Elective Courses.

3. Farm Buildings and Machinery. — A study of the material equipment of the farm aside from the land; farm buildings, their location, plan and arrangement; water supply; fencing problems; farm power; farm machinery; wagons. Prerequisites, Agronomy 1, Animal Husbandry 2, Physics 1. Primarily for seniors; 2 laboratory periods and 1 lecture hour. Credit, 3.
Professor Foord.

4. Farm Management. — The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts. Prerequisites, Agronomy 1 and 3, Animal Husbandry 2 or 3. Primarily for seniors; 2 lecture or recitation hours and 1 laboratory period. Credit, 3. Professor Foord.

POULTRY HUSBANDRY.

Professor Graham, Dr. Goodale, Mr. Payne.

Elective Courses.

1. Elements of Poultry Culture. — This course consists of a comprehensive study of poultry-house construction, poultry-house equipment, feeds and feeding, winter-egg production, types and breeds of poultry. Juniors; 2 lectures. Credit, 2. Professor Graham.

2. Elements of Poultry Culture. — This is a continuation of Course 1, treating the subjects of incubation, brooding, care of growing stock, breeding, market poultry, including capons, roasters and broilers, and diseases of poultry. Juniors; 2 lectures. Credit, 2. Professor Graham.

3. Poultry Practice Work. — This is a practical laboratory course in poultry carpentry, caponizing, killing and picking; dressing and packing poultry, sorting and preparing eggs for market. Must be preceded or accompanied by Course 1. Juniors; 1 laboratory period. Credit, 1. Mr. Payne.

4. Incubation and Brooding. — In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg, and the care of sitting hens. This course must be preceded or accompanied by Course 2. Juniors; time to be arranged. Credit, 1 to 3. Mr. Payne.

6. Poultry Management. — A detailed study of large poultry farms and equipment, such as bone cutters, feed cutters, cramming machines, etc.; the laying out and planning of poultry buildings of all kinds; mating of fowls; attention to poultry diseases and investigation work carried on by experiment stations is prominent. A few good poultry plants will be visited by the class for practical demonstrations. Prerequisites, Courses 1, 2, 3, 4, 7, 9 and 10. Seniors; 2 lectures, 1 laboratory period. Credit, 3. Professor Graham and Mr. Payne.

7. Advanced Poultry Judging. — This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text. Prerequisites, Courses 1, 2, 3, 4 and 5. Seniors; 1 lecture and 2 laboratory periods. Credit, 3. Mr. Payne.

8. Investigational Work. — This course is designed especially for students who are planning to do experiment station work. Students will be assigned specific problems to work out experimentally, or they may be required to assist in carrying on such work. Credit, 1 to 3. Dr. Goodale.

9. Market Poultry and Poultry Products. — This course includes the study of market classifications of poultry, eggs and feathers; the requirements of different markets, methods of marketing, advantages and disadvantages

of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed, and market eggs will be an important feature of this course. Prerequisites, Courses 1, 2 and 3. Seniors; 1 lecture or conference period and laboratory periods to be arranged. Credit, 3. Mr. PAYNE.

10. PEN MANAGEMENT. — This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls, and profit and loss. Prerequisite, Course 1. Juniors; time to be arranged. Credit, 1.
Mr. PAYNE.

RURAL ENGINEERING.

Professor GUNNESS.

Elective Courses.

3. FARM STRUCTURES. — Study of the strength, durability and cost of building materials; water supply; lighting and heating systems for the farm; drawing plans, writing specifications and estimating the cost of buildings; concrete construction as applied to foundations, silos, tanks, posts, floors and walks. One lecture and 2 laboratory periods. Credit, 3.
Professor GUNNESS.

4. FARM MACHINERY. — Study of the care and operation of tillage, seeding, harvesting, pumping and spraying machinery; steam and gas engines. Special attention will be given to the use of power on the small farm. Practice in the adjustment of the various machines, babbitting and fitting bearings, lining shafts and pulleys, lacing belts, splicing rope and packing valves. One lecture and 2 laboratory periods. Credit, 3. Professor GUNNESS.

5. POWER MACHINERY. — Steam and gasoline engines, refrigerating machinery, electric motors and dynamos. Practice in pipe fitting, soldering, babbitting and fitting bearings, lacing belts and packing valves. Course 5 is intended primarily for dairy students, but would be valuable to any man who would expect to use engines, pumps or electrical machinery. One lecture and 2 laboratory periods. Credit, 3. Professor GUNNESS.

6. FARM MECHANICS. — A general study of the farm equipment; farm buildings, their location, plan and arrangement; water supply; sewage disposal; lighting and heating systems; farm power and farm machinery. Course 6 has been planned for the benefit of those students who want a general course in farm mechanics but cannot spend the time to take the two courses, 3 and 4. One lecture and 2 laboratory periods. Credit, 3. Professor GUNNESS.

DIVISION OF HORTICULTURE.

Professor WAUGH.

[The general subject of horticulture divides naturally into subjects of pomology, floriculture, forestry, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.]

2. NURSERY PRACTICE. — This course treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums. Sophomores; 1 lecture period and 1 laboratory period. Credit, 2. Assistant Professor THOMPSON.

Elective Courses (General).

3. PLANT MATERIALS. — This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work and with the methods of propagating them. Prerequisite, Horticulture 2. Two lecture periods and 1 laboratory period. Credit, 3. Assistant Professor THOMPSON.

4. PLANT MATERIALS. — A continuation of Course 3, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions. Prerequisite, Horticulture 3. Two lecture periods and 1 laboratory period. Credit, 3. Assistant Professor THOMPSON.

6. PLANT BREEDING. — This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops. Open only to students well prepared in agricultural or horticultural subjects. Seniors and graduates; 2 lecture periods and 1 2-hour laboratory period. [Not given in 1915-16.] Credit, 3.

FLORICULTURE.

Associate Professor NEHRLING, Mr. THURSTON.

Elective Courses.

1. GREENHOUSE MANAGEMENT. — This course is designed to familiarize students with the methods followed in the management of greenhouse crops. The students are instructed in the practical operations of watering, potting, fumigating, ventilating and in the methods of propagation of plants by seed

and cuttings. They will also be expected to arrange their hours according to the needs of the work. Prerequisite, Horticulture 2. Juniors; 2 lectures, 6 laboratory hours. Credit, 5.

Associate Professor Nehrling and Mr. Thurston.

2. Greenhouse Management. — Continuation of Course 1. In addition, work in the use of cut flowers and plants in decorative work, the arrangement of flowers in baskets, designs, vases, table and home decorations will be considered. Juniors; 2 lectures, 6 laboratory hours. Credit, 5.

Associate Professor Nehrling and Mr. Thurston.

3. Commercial Floriculture. — A detailed study will be made of the methods cultural for greenhouse plants and cut flowers for wholesale and retail markets. The care and marketing of all florists' crops will also be considered. Assigned readings on these topics. Prerequisites, Floriculture 1 and 2. Seniors; 2 lectures, 4 laboratory hours. Credit, 4.

Associate Professor Nehrling.

4. Commercial Floriculture. — As stated under Course 3. Prerequisites, Floriculture 1, 2 and 3.

5. Greenhouse Construction. — The location, arrangement, construction, cost, heating and ventilating of greenhouse structures; also the drawing of plans and drafting of specifications for commercial houses and private ranges. Such practical work as glazing, the construction of concrete benches and cold frames will be included in this course. Should be taken with Floriculture 1. Juniors; 2 lectures, 2 laboratory hours. Credit, 3.

Associate Professor Nehrling and Mr. Thurston.

6. Garden Flowers and Bedding Plants. — This course aims to make the student familiar with those annuals, herbaceous perennials, bulbs and bedding plants used in landscape work. Their propagation, culture and uses will be considered. Assigned readings and field trips. Two lectures, 3 laboratory hours. Credit, 3.

Associate Professor Nehrling and Mr. Thurston.

7. Conservatory Work and Decorative Plants. — A study of the tropical and subtropical foliage and flowering plants used in conservatory work. Their arrangement and care will also be considered. Assigned readings. Should be taken with Course 4. Prerequisites, Floriculture 1, 2 and 3. Two lectures, 2 laboratory hours. Credit, 3. Associate Professor Nehrling.

FORESTRY.

Professor Clark.

Elective Courses.

1. Principles of Forestry. — A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Juniors and seniors; not required of students who propose to major in forestry. Two lectures. Credit, 2.

Professor Clark.

2. Wood Technology. — A study of the commercial woods found in the lumber markets, methods of identification, uses, strength values, technical qualities, decay and methods of preservation. Juniors; 1 lecture and 2 laboratory periods. Credit, 3. Professor Clark.

3. Dendrology. — During the first part of the semester frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Juniors; 2 2-hour periods; lectures, recitations, laboratory or field work at option of instructor. Credit, 3. Professor Clark.

4. Silviculture. — Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting. Prerequisite, Forestry 3. Juniors; 3 lectures weekly until May 1; during May and June, 1 lecture and 1 4-hour field period weekly. Credit, 3. Professor Clark.

5. Forest Mensuration. — Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating. Seniors; 3 lectures, 72 hours of field work. Credit, 5. Professor Clark.

6. Seminar — Report. — This may involve research, laboratory or field work in the investigation of some subject, together with a review of the literature relating to it and an original written report evidencing the results. Subject to be chosen in conference with Professor Clark. Seniors. Credit, 3.
Professor Clark.

LANDSCAPE GARDENING.

Professor Waugh, Assistant Professor Harrison.

Elective Courses.

1. Elements of Landscape Gardening. — Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Students should have preparation in surveying, mathematics, plant materials and drawing. Must be followed by Course 2. Juniors; 6 hours a week. Credit, 3.
Assistant Professor Harrison.

2. Elements of Landscape Gardening. — As stated under Course 1. Prerequisite, Course 1.

3. General Design. — Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports on individual problems. Seniors; prerequisites, Landscape Gardening 1 and 2, and either plant materials (Horticulture 3 and 4) or advanced mathematics; must be followed by Course 4; 6 hours. Credit, 3. Assistant Professor Harrison.

4. General Design. — As stated under Course 3. Prerequisite, Course 3.

5. Theory of Landscape Art. — The general theory and applications of landscape study, including a brief history of the art. Seniors and graduates; 2 hours. Credit, 2. Professor Waugh.

6. Architecture. — The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing; 2 hours. (Alternating with Course 10 and not to be given in 1915–16.) Credit, 2.
Assistant Professor Harrison.

7. Civic Art. — The principles and applications of modern civic art, including city planning, city improvement, village improvement and rural improvement with special emphasis upon country planning. Prerequisites, Courses 1, 2 and 3; must be followed by Course 8. Six hours. Credit, 3.
Professor Waugh.

8. Civic Art. — As stated under Course 7. Prerequisite, Course 7.

10. Construction and Maintenance. — Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc. (Alternating with Course 6.) Two hours. Credit, 2. Assistant Professor Harrison.

MARKET GARDENING.

Professor Tompson, Assistant Professor Thomson.

Elective Courses.

2. Elements of Market Gardening. — A course designed for an introduction to market gardening as a business. The work consists primarily of actual field experience in handling vegetable crops from seed to maturity. This is supplemented with lectures and text-book, in which a study of methods, soils, fertilization, tillage and management is made. Juniors; 5 hours. Credit, 3. Assistant Professor Thomson.

3. Advanced Market Gardening. — A continuation of the work begun in Market Gardening 2, taking up problems of seed growing, selection of varieties, crop management, harvesting, storage and marketing. A study is made of the greenhouse vegetable industry, and considerable time devoted to growing the special forced crops. Some time is given to a systematic study of vegetable description, classification and nomenclature. Collateral reading is required. Seniors; prerequisite, Market Gardening 2; 5 hours. Credit, 3. Assistant Professor Thomson.

POMOLOGY.

Professor SEARS, Associate Professor CHENOWETH.

Elective Courses.

1. PRACTICAL POMOLOGY 1. — A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery stock, pruning, culture of orchards, orchard fertilizers, cropping orchards, etc. Text and reference books; field and laboratory exercises. Prerequisite, Horticulture 2. Juniors; 4 hours. Credit, 3. Professor SEARS.

2. PRACTICAL POMOLOGY 2. — As stated under Course 1. Prerequisites, Horticulture 2 and Pomology 1. Juniors; 4 hours. Credit, 3. Professor SEARS.

3. SYSTEMATIC POMOLOGY. — A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Text-books, laboratory and field exercises. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 4 hours. Credit, 3. Associate Professor CHENOWETH.

4. SYSTEMATIC POMOLOGY. — As stated under Course 3. Prerequisites, Horticulture 2 and Pomology 1, 2 and 3. Seniors; 4 hours. Credit, 3.

5. COMMERCIAL POMOLOGY. — The picking, handling, storing and marketing of fruits, including a discussion of storage houses, fruit packages, methods of grading and packing, manufacturing, etc. Especial emphasis is placed upon laboratory and field work, where the student is given actual practice in the picking and packing of all the principal fruits, together with the manufacture of by-products. Open only to men majoring in pomology. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 1 lecture and 2 laboratory periods. Credit, 3. Associate Professor CHENOWETH.

6. SPRAYING. — A study of (*a*) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (*b*) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (*c*) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small fruit plantations. Prerequisites, Horticulture 2 and Pomology 1 and 2. Seniors; 3 hours. One lecture period and 1 laboratory period. Credit, 2. Professor SEARS.

DRAWING.

Mr. Root.

Elective Courses.

1. Free-hand Drawing. — Lettering; free-hand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink. Juniors; 6 hours. Credit, 3.

Mr. Root.

2. Mechanical Drawing. — Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry. Juniors; 6 hours. Credit, 3.

Mr. Root.

DIVISION OF SCIENCE.

Professor Henry T. Fernald.

BOTANY.

Professor Stone,[1] Associate Professor Osmun, Assistant Professor Anderson, Mr. McLaughlin, Mr. Smith, Mr. Doran.

[The object of the courses in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. Undergraduate work extending through five semesters is offered. Students sufficiently prepared are occasionally permitted to undertake special physiological and pathological investigations. A botanical conference is held weekly, wherein new problems in botanical science are considered by graduate students and the seniors who elect botany. A complete revision of the courses offered by the department will appear in the spring supplement of this catalogue.]

Required Course.

2. General Botany. — The morphology, physiology and classification of plants. This course is fundamental. Its aim is to lay a foundation for the more specialized courses in botany which follow, and to provide a general knowledge of the science for those students who will not take further work in the department. This course is prerequisite to all other courses given by the department. In the laboratory much time is devoted to study of the structure of higher or seed plants. In this work first attention is given to the cell as the unit of structure; from the cell is traced the gradual development of the tissues of the entire plant. During the spring period of the semester much practice is given in determining and naming plants, Gray's "New Manual of Botany" being employed. In connection with this work each student is required to collect and prepare an herbarium of 75 species of plants. The lectures aim to amplify and interpret the laboratory work, dealing also with the function (physiology), classification (taxonomy) and ecology of plants. Though only 1 lecture period is scheduled for this course, it is understood that laboratory hours may be used for lectures at the discretion of the instructor. Sophomores; 1 lecture and 3 laboratory periods. Credit, 4.
Associate Professor Osmun, Mr. McLaughlin, Mr. Smith and Mr. Doran.

Elective Courses.

3. Cryptogamic Botany. — Systematic study of typical forms of the lower plants (bacteria, algæ, fungi, lichens, mosses and ferns); instruction in laboratory technique and methods; field excursions for the purpose of observing environmental habits and collecting material for laboratory study; collateral reading. This course is intended for those students who wish to specialize in any of the biological sciences, and is a prerequisite of Courses 9, 10, 15 and 16. Students electing this course may attend the lectures in Course 5. Prerequisite, Course 2. Primarily for juniors; 1 lecture hour and 3 2-hour laboratory periods. Credit, 4. Mr. McLaughlin.

4. Cryptogamic Botany. — As stated in Course 3. Prerequisite, Course 3. One lecture hour and 2 2-hour laboratory periods. Credit, 3.

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[1] Absent on leave; Associate Professor Osmun acting as head of department.

5. Diseases of Crops. — This course comprises a study of the common diseases of crops, their nature, causes and methods of prevention and control. In the laboratory macroscopic examinations of diseases are made, and the principal experiment-station and government literature on plant diseases is read. Intended especially for students majoring in agronomy, floriculture, landscape gardening and pomology. Prerequisite, Course 2. Primarily for juniors; 1 1-hour lecture and 1 2-hour laboratory period. Credit, 2.
Assistant Professor Anderson, Mr. McLaughlin and Mr. Smith.

7. Diseases of Crops. — This course is more specialized than Course 5, and is intended to meet the needs of the student who wishes to make a more thorough study of the diseases of the particular group or groups of crops in which his interest lies; *e.g.*, diseases of fruits, diseases of field crops, diseases of trees and shrubs. Laboratory work consists of microscopic and macroscopic examination of diseases, and extensive reading of literature concerning them. Prerequisite, Course 2. Students taking this course who have not previously taken Course 5 will attend the lectures in Course 5, and if they continue in botany the second semester, must take Course 8. Seniors; 1 lecture and 3 2-hour laboratory periods. Credit, 4. Assistant Professor Anderson.

8. Diseases of Crops. — As stated in Course 7. Prerequisite, Course 7.

9. Plant Pathology. — This course embraces a comprehensive study of diseases of plants, including detailed training in laboratory methods and technique. Much time is devoted to the study of literature and representative life histories of pathogens, the making of pure cultures, and artificial inoculation of hosts. Students taking this course are fitted for civil service, experiment-station and college positions in plant pathology. Course 10 must follow. Prerequisites, Botany 2, 3 and 4. Seniors; 1 lecture and 4 2-hour laboratory periods. Credit, 5. Associate Professor Osmun.

10. Plant Pathology. — As stated in Course 9. Prerequisite, Course 9.

11. Plant Physiology. — This is a general course dealing with such topics as absorption, nutrition, growth, movement and the tropisms of plants, and requires previous training in organic chemistry and botany. Prerequisite, Botany 2. Seniors; 1 lecture and 3 2-hour laboratory periods. Credit, 4.
Assistant Professor Anderson and Mr. Doran.

12. Plant Physiology. — As stated in Course 11. Prerequisite, Course 11.

13. Shade-tree Management. — Physiology and pathology of shade-trees. This course includes a comprehensive study of the diseases, structure and functions of trees and shrubs, and of every agency which in any way affects shade-trees. Laboratory work and lectures; extensive reference reading. Designed for those students who intend to take charge of parks or large estates, or to become tree wardens, city foresters, landscape gardeners or professional advisers and caretakers. Prerequisite, Courses 2 and 5. Must be followed by Course 14. Seniors; 1 lecture period and 3 2-hour laboratory periods. Credit, 4. Mr. Smith.

14. Shade-tree Management. — Physiology and pathology of shade-trees, as stated in Course 13. Prerequisite, Course 13.

15. Histological Technique. — This course comprises training in general histological methods, including the use of precision microtomes and various methods of killing, fixing, sectioning, staining and mounting of plant materials. This is a technical course in histology, of value to students intending to become research or teaching botanists. It is recommended for students taking Courses 9 and 10, as an aid to the study of relationship between host and parasite, and is open to those taking Courses 13 and 14, who desire to make their studies in tree structure more comprehensive. Collateral reading and conferences. Prerequisites, Botany 2, 3 and 4. Seniors; 3 or 5 2-hour laboratory and conference periods. Credit, 3 or 5.

Associate Professor Osmun.

16. Histological Technique. — As stated in Course 15. Prerequisite, Course 15.

GENERAL AND AGRICULTURAL CHEMISTRY.

Professor Lindsey, Professor Wellington, Professor Chamberlain, Associate Professor Peters, Associate Professor Anderson, Mr. Serex, Mr. Erichsen, Mr. MacNeil, Mr. Perry, Mr. Phillips.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and intending following chemistry as a vocation are prepared for positions as instructors in high schools and colleges in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer, cattle food, sugar and dairy industries. Students are encouraged to take graduate work leading especially to the degree of M.Sc., and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1A. General Chemistry. — An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds. Text-book, Kahlenberg's "Outlines of Chemistry." This course is for those students who do not present chemistry for entrance, and who begin the subject in college. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor Peters, Mr. Serex, Mr. Erichsen
and Mr. Perry.

1B. Advanced General Chemistry. — A review of the fundamental chemical laws, together with the common acid and base-forming elements and their compounds. Text-book, Kahlenberg's "Outlines of Chemistry." The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate, superphosphate, muriate and sulfate of potash, arsenate of lead, Paris green, Bordeaux mixture, lime-sulfur and emulsions. In addition to these, preparations outlined in Blanchard's "Synthetic Inorganic Chemistry" are made. This course is for students who present chemistry for entrance. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor ANDERSON, Mr. SEREX, Mr. ERICHSEN and Mr. PHILLIPS.

2A. GENERAL CHEMISTRY. — A continuation of Course 1A. A study of metals and their compounds. The laboratory work is the same as described under 1B. Associate Professor PETERS and Assistants.

2B. INORGANIC AGRICULTURAL CHEMISTRY. — A study of the chemical composition, properties and reactions of soils, fertilizers, fungicides and insecticides, and the common materials of construction, such as tile, brick, cements, paints, etc. Text-book, Fraps' "Principles of Agricultural Chemistry." The laboratory work is divided into three parts, as follows: (*a*) qualitative examination of soil, plant ash and superphosphate; (*b*) approximate quantitative determination of moisture, ash, carbonic acid, phosphoric acid, potash, etc.; (*c*) special work on retention of salts by soil, leaching of lime from the soil by carbonated water, etc. Prerequisite, Course 1B. Freshmen; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor ANDERSON and Assistants.

Elective Courses.

3. QUALITATIVE ANALYSIS. — *Basic.* — A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' "Qualitative Analysis," with Böttger's "Qualitative Analysis" and Treadwell-Hall's "Qualitative Analysis" for reference. Prerequisite, Course 2; should be taken, particularly, by all intending to follow chemistry as a vocation. Sophomores; lecture, 1 hour; laboratory, 4 hours. Credit, 3.

Associate Professor ANDERSON and Mr. PHILLIPS.

4. QUALITATIVE ANALYSIS. — *Acidic.* — A continuation of Course 3. A large part of the semester is spent in the examination qualitatively of minerals and of agricultural products. Prerequisite, Course 3. Sophomores; lecture, 1 hour; laboratory, 4 hours. Credit, 3.

Associate Professor ANDERSON and Mr. PHILLIPS.

5. ORGANIC CHEMISTRY. — This course, with Course 6, continues through the junior year. The two courses are designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured

from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for future work in agricultural chemical investigation. Prerequisites, Courses 1, 2, 3 and 4 (Courses 3 or 4 will not be required as prerequisites for those majoring in other courses than chemistry). Juniors; those electing Course 5 are expected to elect Course 6; lectures, 3 hours; laboratory, 4 hours. Credit, 5.

Professor CHAMBERLAIN and Mr. PERRY.

6. As stated under Course 5.

[AGRICULTURAL CHEMISTRY. — The two following courses in general agricultural chemistry are designed especially for students majoring in the different departments of the Divisions of Agriculture and Horticulture, and every effort is made to meet the demands of these departments. They are for students in practical agriculture, and not for those intending to take up scientific lines of work. They form an alternative group with either Courses 3 and 4 or 5 and 6.]

7. INORGANIC AGRICULTURAL CHEMISTRY. — The same as Course 2B. This course is designed for those men who have had only Courses 1A and 2A. Prerequisites, Courses 1A and 2A. Juniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3. Associate Professor ANDERSON and Mr. PHILLIPS.

8. ORGANIC AGRICULTURAL CHEMISTRY. — The course embraces the study of the most important groups of organic compounds of plants and animals, the composition of plants, the chemistry of plant growth, plants as food and as industrial material, the composition of animals, the chemistry of digestion, absorption and metabolism, animal nutrition, animal foods, rations, etc., and also the study of some of the products related to plants and animals, such as milk, butter, cheese, sugar, alcohol, wood pulp and paper. The treatment of the subject will be general, avoiding (so far as possible) complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the general chemistry of plants and animals and agricultural processes and products. Prerequisites, Courses 1 and 2. Juniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Professor CHAMBERLAIN and Mr. PERRY.

9. QUANTITATIVE ANALYSIS. — Instruction in this course includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals in minerals and industrial products. Aside from teaching accurate observation and care in manipulation, it is intended for those who would learn the exact methods for determining the elements, particularly, in inorganic substances, and is the forerunner of other courses intended to fit men to become expert analysts. Talbot's "Quantitative Chemical Analysis" is used as a text. Prerequisites, Courses 1, 2 and 3 or 4. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON, Associate Professor PETERS and Mr. MACNEIL.

10. AGRICULTURAL CHEMICAL ANALYSIS. — In this course and Course 11 the methods previously studied, and other approved methods, are applied to the examination of agricultural materials. The analysis of fertilizers, in-

secticides, fungicides and soils is followed by that of cattle foods, dairy products, sugars, starches and allied substances. Prerequisite, Course 9. Juniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5.

Professor WELLINGTON, Associate Professor PETERS and Mr. MACNEIL.

11. AGRICULTURAL CHEMICAL ANALYSIS. — As stated under Course 10. Prerequisite, Course 10. Seniors; lecture, 1 hour; laboratory, 8 hours. Credit, 5. Associate Professor PETERS and Mr. MACNEIL.

12, 14 and 16. See below, following Course 15.

13. PHYSIOLOGICAL CHEMISTRY. — This course is intended to be supplementary to Courses 5 and 6 and Courses 7 and 8. To those who expect to take up scientific work in microbiology, botany, agronomy, animal husbandry, etc., and who have had Courses 5 and 6, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 5 and 6 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory, experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment-station work, especially those connected with investigations in animal and plant nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems which were treated generally in Courses 7 and 8. Prerequisites, preferably, Courses 5 and 6 or 7 and 8. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3. Professor CHAMBERLAIN and Mr. PERRY.

15. PHYSICAL CHEMISTRY. — A résumé of general chemistry from the viewpoint of physical chemistry and the application of physical chemistry to agricultural chemistry. Prerequisite, Course 9. Seniors; lectures, 2 hours; laboratory, 2 hours. Credit, 3.

Associate Professor ANDERSON and Mr. PHILLIPS.

[GENERAL STATEMENT CONCERNING COURSES 12, 14 AND 16. — Each student electing either of these courses will be required to take up and follow out some special line of work, the object being to acquaint him with methods of original inquiry. A single concrete example may be found in a comparative study of the different methods for the determination of the several forms of nitrogen. A thesis may not be required, but frequent consultation of the literature bearing on the subject will be necessary. These courses are valuable for all chemists, and particularly so for those intending to take up experiment-station work. A student may choose any one but not two of these separate courses.]

12. SPECIAL WORK IN AGRICULTURAL CHEMICAL ANALYSIS. — The student is given a problem to solve either in analytical chemistry or related to the agricultural industries. This will acquaint him with the methods used in research and with the literature, and show him how to handle problems in this field of chemistry when occasion arises.

Associate Professor PETERS.

14. Special Work in Physiological and Organic Agricultural Chemistry. — In this course, as in Courses 12 and 16, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, the chemical study of dairy products, etc. Prerequisites, Courses 5, 6 and 13. Seniors; laboratory, 10 hours. Credit, 5.
Professor Chamberlain.

16. Special Work in Physical Chemistry. — The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work. Prerequisite, Course 15. Laboratory, 10 hours. Credit, 5.
Associate Professor Anderson.

18. History of Chemistry. — An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course. Seniors; lectures, 2 hours. Credit, 2.
Professor Wellington.

ENTOMOLOGY.

Professor Fernald, Professor Crampton, Associate Professor Gates, Dr. Regan.

Elective Courses.

1. General and Economic Entomology. — Course 1 comprises a general introduction to the study of insects, including studies on their structure as applied to their identification; the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collections, and methods for their control. The most important insecticides and their preparation and application are also treated. Students electing Course 1 are expected to take Course 2. Juniors; 3 lecture periods. Credit, 3. Professor Fernald.

2. General and Economic Entomology. — A continuation of Course 1, with laboratory and field work on methods of collecting, preserving and studying insects and their work. Prerequisite, Entomology 1. Juniors; 2 laboratory or field periods. Credit, 2. Professor Fernald.

3. Advanced Entomology. — This course is subdivided, the time spent on the various subdivisions differing somewhat according to the particular needs of those taking it; and it is to a large degree given in the form of in-

dividual instruction, special attention being paid to the pests attacking the particular crops in which the student is most interested. The student may specialize in fruit pests, market-garden pests, greenhouse pests, field crop pests, etc., to a large extent, in accordance with his plans for future work.

A. Morphology. — Careful studies of the structure of insects belonging to each of the larger and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. Histology. — Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. Insecticides and Apparatus. — Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects; tests for detecting adulterations; comparative tests of nozzles and other apparatus; and a study of other methods of insect control, together with laboratory work.

D. Coccidology. — Lectures and laboratory work on methods of preserving, mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. Bibliography. — Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. Special Studies. — In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's "Manual for the Study of Insects" is used in the laboratory work. Seniors; prerequisite, Entomology 2; students electing Course 3 are expected to take Course 4; 1 1-hour lecture period and 3 2-hour laboratory or field periods. Credit, 4. Professor FERNALD and Associate Professor CRAMPTON.

4. ADVANCED ENTOMOLOGY. — As stated in Course 3. Prerequisite, Course 3.

5. FOREST AND SHADE-TREE INSECTS. — A study of the insects injurious to forest and shade-trees, and of methods for their control, with laboratory and field work on these insects, and a study of what has been published about them. Seniors; prerequisites, Entomology 1 and 2; 1 lecture and 2 2-hour laboratory or field exercises. Credit, 3. Professor FERNALD.

8. BEEKEEPING. — This course comprises a general consideration of the biology of the honeybee and the elements of practical beekeeping. Some topics covered are: life history, general behavior and instincts, structure, products, relations of bees to plants, the honey flora. The course aims particularly to afford first-hand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental, are emphasized. So far as possible the work is made individual in con-

structing materials and apparatus and in the manipulation of bees. Juniors; seniors may elect; Courses 1 and 2 form a desirable preparation; 2 lectures, 1 2-hour laboratory period. Credit, 3. Associate Professor Gates.

10. Advanced Beekeeping. — This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management, including the principles of queen rearing, are practiced. The course should further qualify for apicultural instruction and inspection service, affording familiarity with the special literature and methods needed in investigation and research. The policy of individual instruction is continued in so far as practicable. Primarily for seniors, but juniors may elect; prerequisite, Course 8: 1 lecture, 1 2-hour laboratory period. Credit, 2. Associate Professor Gates.

11. Evolution. — In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the appearance of man; his future in the light of his past development; and the evolution of human institutions and ideas. Consideration is also given to the theories concerning the factors of evolution, the general problems of heredity and similar topics. The course closes with a brief discussion of the philosophical, moral and social aspects of the problems involved, and the influence of the idea of evolution upon modern thought. The lectures are supplemented by collateral reading; and a portion of the time is used for the purpose of demonstration, or discussion by the class. Seniors; juniors may elect; 2 lecture periods. Credit, 2. Professor Crampton.

MATHEMATICS AND CIVIL ENGINEERING.

Professor Ostrander, Assistant Professor Duncan, Assistant Professor Machmer, Mr. Hazeltine.

Required Courses.

1. Higher Algebra. — A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, variation, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra." Freshmen; 3 hours a week. Credit, 3.

Assistant Professor Duncan, Assistant Professor Machmer and Mr. Hazeltine.

2. Higher Algebra. — As stated under Course 1, but for two hours only. Credit, 2.

3. SOLID GEOMETRY. — Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Freshmen; required unless accepted for admission; 2 hours a week. Credit, 2.

Assistant Professor DUNCAN, Assistant Professor MACHMER and Mr. HAZELTINE.

4. PLANE TRIGONOMETRY (in charge of Department of Physics). — The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry." Freshmen; 3 hours. Credit, 3. Professor HASBROUCK and Assistant Professor ROBBINS.

Elective Courses.

5. MENSURATION AND COMPUTATION. — The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule. Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of woodworking; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements. Primarily for juniors; 3 hours. Credit, 3.

Assistant Professor MACHMER.

6. PLANE SURVEYING. — The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures. Sophomores; 6 hours a week. Credit, 3.

Professor OSTRANDER, Assistant Professor DUNCAN, Assistant Professor MACHMER and Mr. HAZELTINE.

7. ANALYTIC GEOMETRY. — A discussion of the geometry of the line, the circle, of conic sections and of the higher plane curves. Fine and Thompson's "Coördinate Geometry." Prerequisites, Mathematics 1, 2, 3 and 4. Primarily for juniors; 3 hours a week. Credit, 3.

Professor OSTRANDER.

8. DIFFERENTIAL AND INTEGRAL CALCULUS. — A first course in the subject, with some of the more important applications. Davis's "Differential and Integral Calculus." Prerequisites, Mathematics 1, 2, 3, 4 and 7. Primarily for juniors; 5 hours. Credit, 5. Assistant Professor DUNCAN.

10. ROADS AND RAILROADS. — Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Text-book and lectures; 6 hours. Credit, 5. Professor OSTRANDER.

11. HYDRAULICS AND SANITARY ENGINEERING. — Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Text-book and lectures; 3 hours. Credit, 3.
Professor OSTRANDER.

12. ELEMENTARY STRUCTURES. — An elementary course in roofs and bridges. Text-book and lectures; 6 hours. [Not given in 1915–16.] Credit, 5.
Professor OSTRANDER.

13. MATERIALS OF CONSTRUCTION, FOUNDATIONS AND MASONRY CONSTRUCTION. — Text-book and lectures; 4 hours. [Not given in 1915–16.] Credit, 3. Professor OSTRANDER.

15. APPLIED MECHANICS. — A course in applied mechanics, based on the calculus, with problems. Text-books and lectures. Prerequisite, Mathematics 8. Three hours. Credit, 3. Professor OSTRANDER.

MICROBIOLOGY.

Professor MARSHALL, Associate Professor VAN SUCHTELEN, Mr. ITANO, Mr. AVERY.

[Courses 1 and 3 (repeated in 2 and 4) are especially adapted to those who wish a general, comprehensive, although elementary, survey of agricultural microbiology.]

Elective Courses.

1. MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY. — Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses offered; 2 hours or 2 credits are assigned to lectures, text-book requirements and recitations; this time will be scheduled. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 5. The DEPARTMENT.

2. As stated under Course 1, which it repeats.

3. AGRICULTURAL MICROBIOLOGY. — This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture, — the microbiological features of air, water, sewage, soil, dairy, fermentations, food, vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices. These subjects will be demonstrated by illustrative and typical laboratory exercises, which for each subject, on account of time limitations, must be very elementary and greatly restricted. Prerequisite, Microbiology 1 or 2. Two hours or 2 credits are assigned to lectures, text-book requirements and recitations; this time will be scheduled. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 5. The DEPARTMENT.

4. As stated under Course 3, which it repeats.

5. Advanced Morphological, Cultural and Physiological Microbiology. — The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of micro-organisms and their functions. Prerequisites, Microbiology 1 or 2, 3 or 4, and Chemistry 5 and 6. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors in the fall and spring semesters. Credit, 3.

The Department.

6. As stated under Course 5, which it repeats.

7. Advanced Agricultural Microbiology. — A knowledge of the subjects mentioned in Courses 3 and 4 cannot be obtained without a more extensive training in microbiological practices, as found in Courses 5 and 6. Prerequisites, Microbiology 1 or 2, 3 or 4 and 5 or 6, and Chemistry 5 and 6. Six hours or 3 credits are assigned to the laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors in the fall and spring semesters. Credit, 3.

The Department.

8. As stated under Course 7, which it repeats.

9. Soil Microbiology. — Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. Prerequisite, Microbiology 1 or 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3.

The Department.

10. As stated under Course 9, which it repeats.

11. Dairy Microbiology. — Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bacterial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered. Prerequisites, Microbiology 1 or 2, and Dairying 1 (see Dairying 3). Six hours or 3 credits are assigned to laboratory exercises; only 1 hour of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3. The Department.

12. As stated under Course 11, which it repeats.

13. Food Microbiology. — A study of food preservation by means of drying, canning, refrigerating and addition of chemicals will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance and will be demonstrated by laboratory exercises. Prerequisite, Microbiology 1 or 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3. The Department.

14. As stated under Course 13, which it repeats.

15. Hygienic Microbiology. — An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control, including disinfectants and disinfection, antiseptics, antisepsis and asepsis will be treated. Prerequisite, Microbiology 1 or 2. Six hours or 3 credits are assigned to laboratory exercises; only 1 of the 6 is scheduled; the remaining 5 hours are arranged with the instructor. Open to juniors and seniors. Credit, 3.

The Department.

16. As stated under Course 15, which it repeats.

PHYSICS.

Professor Hasbrouck, Assistant Professor Robbins, Mr. Thompson.

[The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoölogy, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective.]

Required Course.

1. General Physics: Mechanics of Solids and Fluids, Wave Motion and Heat. — The following topics are chosen for the required work because they are regarded as the most fundamental of all, and there is no part of the work in physics more necessary for the student who plans to take up practical farming: Statics, with equilibrium of rigid body, work, energy and friction; kinetics, considering rectilinear motion and motion in a curved path; harmonic motion; rotation of rigid bodies, including kinematics of rotation; liquids and gases, with properties of fluids at rest and in motion; properties of matter and its internal forces, including elasticity, capillarity, surface tension; heat, including thermometry, calorimetry and specific heat, transmission of

heat, changes of state, radiation and absorption. Course given by text-book and lectures. Sophomores; 4 hours class-room work and 1 laboratory period. Credit, 5.

Professor Hasbrouck, Assistant Professor Robbins and Mr. Thompson.

Elective Courses.

2. General Physics: Electricity and Light. — The work in electricity includes such subject-matter as magnetism, electrostatics, electric currents with their production, chemical, heating and mechanical effects; battery cells, measurement of voltage, current flow and resistance, motors and generators. In "light" there is included photometric measurements of the intensity of light, refraction, reflection and dispersion of light, lenses, prisms and optical instruments; analysis of light and polarization. Text-book, lectures, recitations and laboratory work. Sophomores; 2 hours of class-room work and 1 laboratory period. Credit, 3.

Assistant Professor Robbins and Mr. Thompson.

3. Electricity, Heat and Light. — Three-hour lecture and laboratory course open to juniors and seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Assistant Professor Robbins.

4. Continuation of Course 3, open to juniors and seniors; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3. Assistant Professor Robbins.

[Mathematics 4 (trigonometry) is, for convenience of grouping, listed under mathematics, although in charge of the Department of Physics.]

VETERINARY SCIENCE.

Professor Paige, Associate Professor Gage.

[The courses in veterinary science have been arranged to meet the needs of students who propose following practical agriculture, and of prospective students of human and comparative medicine.]

Elective Courses.

1. Veterinary Hygiene and Stable Sanitation. — This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

2. General Veterinary Pathology, Materia Medica and Therapeutics. — In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in pathology is followed by one in materia medica and therapeutics, dealing with the origin, preparation, pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

3. Comparative (Veterinary) Anatomy. — The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 4. Juniors and seniors; 3 hours. Credit, 3. Professor Paige.

4. Theory and Practice of Veterinary Medicine; General, Special and Operative Surgery. — A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technic of simple surgical operations that can with safety be performed by the stock owner. This course should be preceded by Course 3, and taken in conjunction with Course 2. Lectures, demonstrations and practice. Juniors and seniors; 3 hours. Credit, 3.

Professor Paige.

5. Essentials of General Pathology. — This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

6. Essentials of General Animal Pathology. — This is a continuation of Course 5, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

7. Avian Pathology. — A course in poultry diseases. The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor Gage.

8. Avian Pathology. — A continuation of Course 7, devoted to the study of some of the special diseases of poultry. Recent methods used in the control

of these diseases will be considered and opportunity offered the student for demonstrating various disease processes by means of prepared slides. Lectures, demonstrations and laboratory work. Juniors and seniors; 2 3-hour laboratory periods. Credit, 3. Associate Professor GAGE.

ZOÖLOGY AND GEOLOGY.

Associate Professor GORDON, Mr. BLANCHARD.

ZOÖLOGY.

Required Course.

1. ELEMENTARY ZOÖLOGY. — This course presents the underlying principles of biology and the zoölogical part of an introductory course. Laboratory dissection and lectures. Sophomores; 1 lecture hour and 2 2-hour laboratory periods. Credit, 3.
Associate Professor GORDON and Mr. BLANCHARD.

Elective Courses.

3. INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — These are separate courses running throughout the year. The student may elect one or the other, but not both in the same year. The course in invertebrate zoölogy is designed primarily for students who are planning to take up entomology, but is open to any one. The course in vertebrate zoölogy deals with comparative vertebrate anatomy and physiology and is designed for those who desire or require a knowledge of the comparative anatomy and physiology of vertebrated animals. Each course includes laboratory, text-book and lecture work. These courses are scheduled in the junior year, but are open to seniors; hours by arrangement. Credit, 3. Associate Professor GORDON.

4. INVERTEBRATE OR VERTEBRATE ZOÖLOGY. — The continuation and completion of Course 3 of the first semester; hours by arrangement. Credit, 3.
Associate Professor GORDON.

5. ELEMENTS OF HISTOLOGY. — This course gives the theories and methods of preparing normal animal tissues for microscopic examination. Chiefly laboratory work, with reading and occasional seminars. Open to juniors and seniors; hours by arrangement; see below, Course 6. Credit, 2.
Mr. BLANCHARD or Associate Professor GORDON.

6. ELEMENTS OF HISTOLOGY. — In Course 6 the student may carry forward the work of the first semester, thereby completing a year's work, or may take the work outlined for Course 5. Open to juniors and seniors; hours by arrangement. Credit, 2.
Mr. BLANCHARD or Associate Professor GORDON.

7. ADVANCED ZOÖLOGY.[1] — Special elective work in advanced zoölogy is offered to seniors who are interested in zoölogy or who are looking forward to advanced work in any department of zoölogy or allied branches; hours by arrangement. Credit, 5.
Associate Professor GORDON and Mr. BLANCHARD.

8. ADVANCED ZOÖLOGY.[1] — This course may be a continuation of the work of the first semester or of separate character; hours by arrangement. Credit, 3. Associate Professor GORDON and Mr. BLANCHARD.

GEOLOGY.

Elective Course.

2. ELEMENTARY GEOLOGY. — Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work. Sophomores; 1 1-hour period and 2 2-hour periods. Credit, 3.
Associate Professor GORDON and Mr. BLANCHARD.

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[1] The work offered in Courses 3, 4, 7 and 8 may apply on a minor for the degrees of master of science or doctor of philosophy.

DIVISION OF THE HUMANITIES.

Professor SPRAGUE.

ECONOMICS AND SOCIOLOGY.

Professor SPRAGUE.

[The courses in economics and sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.]

Elective Courses.

1. POLITICAL ECONOMY. — An introductory course which takes up the study of the nature and scope of economics, the evolution and organization of the present economic system, and the fundamental principles of production, exchange and consumption. The class will study and discuss such topics as wealth, value, capital, interest, profits, wages and labor, tariffs, trusts, etc. Debates on current economic problems will be organized in the class. Text-book, library readings, lectures and discussions. Arranged primarily for juniors; open to seniors; 3 hours. Credit, 3. Professor SPRAGUE.

2. INDUSTRIAL PROBLEMS. — This is a course in the most important industrial problems of the day, covering the methods of organizations of labor and capital, systems of industrial remuneration, means of securing industrial peace, legal status of labor unions and their activities, protective legislation for workmen and employers, the problems of immigration, the sweated industries, prison labor, child labor and industrial education. Text-book, with collateral readings, lectures and discussion. Three hours. Credit, 3.

Professor SPRAGUE.

4. ANTHROPOLOGY; THE HISTORY OF HUMAN CIVILIZATION. — The evolutionary origin and history of man; characteristics of primitive men, departure from the animal status, and the beginnings of civilization; development of industries, arts and sciences; the growth of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern conditions; characteristics of the leading races of the world. These topics will constitute the subject-matter of the course. Arranged for sophomores and juniors; library readings, text-book and lectures; 3 hours. Credit, 3. Professor SPRAGUE.

5. PUBLIC FINANCE, MONEY AND BANKING. — This course follows Economics 1. It will take up taxation and the various systems for collecting public revenue in Europe and America, with the problems involved; the history of money and the systems of banking and finance now in operation; the cause and problems of economic crises and depressions; the currency problems of the United States. For juniors and seniors; readings, lectures and discussions; 3 hours. Credit, 3. Professor SPRAGUE.

7. SOCIAL INSTITUTIONS AND SOCIAL PROBLEMS. — This course is devoted to the study of the social institutions, such as the family, the church, State

and property; and to such current social problems as divorce, race suicide, crime and prison reform, poverty and its relief. Considerable time is given to the study of eugenics in its social significance and possibilities. The correctional and charitable institutions of Massachusetts are studied in some detail. The later weeks of the term are devoted to a short introduction to sociological theory. Arranged especially for seniors; open to juniors by permission; readings, lectures, discussions; 3 hours. Credit, 3. Professor SPRAGUE.

8. MODERN SOCIAL REFORM MOVEMENTS. — The history of property and its vital issues in modern times; the socialistic systems, anarchy and communism; systems of workingmen's insurance in Europe and America, and other methods of relief from the chances of life; educational reforms, in process, to meet the demands of a new age, and legislative remedies for the evils of social change and maladjustment; the crisis of Christianity under modern capitalized industrialism. These topics indicate the nature of the subjects studied. This course is arranged to follow Economics 7. Three hours. Credit, 3.
Professor SPRAGUE.

HISTORY AND GOVERNMENT.

Elective Courses.

1. ELEMENTS OF POLITICAL SCIENCE. — Nature and scope of political science; origin and evolution of the State; systems of government in the principal European States; organization and working of the national and of the State governments of the United States; relation of government to political parties and to public opinion; the functions of government as related to labor and commerce. [Withheld in 1915–16.] Three hours. Credit, 3. ————

2. LOCAL POLITICAL INSTITUTIONS. — A comparative study of the organization, functions and achievements of country and city groups, especially as these are concerned with such matters as taxation, finance, licenses, franchises, public ownership, highways, transportation and communication, water supply, fire protection, public lighting, markets, food inspection, garbage and sewage disposal, infectious diseases, housing conditions, police force, parks and playgrounds, libraries, schools, care of dependents. [Not given in 1915–16.] Three hours. Credit, 3. ————

3. THE HISTORY OF NEW ENGLAND. — This course, treating New England as a unit, aims to give a survey of its political, religious and economic history; to trace the development of its institutions, the growth of its industries, and its influence in national politics and upon the newer sections of the United States. Assigned readings and themes. Juniors and seniors. Three hours. Credit, 3. ————[1]

5. THE HISTORY OF IDEALS. — This course treats history from the idealistic rather than from the economic point of view. It attempts to define the great ideals which have impelled some of the most important social,

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[1] Given in 1915 by Miss Jefferson.

political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. [Withheld in 1915–16.] Lectures and reading. Three hours. Credit, 3. ————

LANGUAGES AND LITERATURE.

Professor Lewis, Associate Professor Neal, Associate Professor Ashley, Associate Professor Mackimmie, Assistant Professor Smith, Assistant Professor Prince, Miss Goessmann, Mr. Harmount, Mr. Julian, Mr. Rand.

English.

Required Courses.

1, 2. Freshman English. — Composition. Recitations, laboratory practice and lectures; theme writing and conferences. Text-book and laboratory manual, Neal's "Thought-Building in Composition." Freshmen; 4 hours. Credit, 4.

Assistant Professor Smith, Assistant Professor Prince and Mr. Rand.

3, 4. Sophomore English. — A general reading course in English literature. Prerequisite, Courses 2 and 3, respectively. Sophomores; 2 hours. Credit, 2. Professor Lewis and Miss Goessmann.

Elective Courses in English Language and Literature.

[The elective courses in English fall into two groups. Both groups are intended to increase the student's appreciation of literature as a means to enjoyment, education and spiritual growth. Group one (Courses 11, 12, 13 and 14) will, besides introducing the student to individual writers, emphasize the life and thought of the times, political, economic and social, in order that the student may realize literature as the expression of individual genius representing (by leading it or summarizing it) the thought and spirit of a period or a social unit. Group two (Courses 15 and 16) will tend more to emphasize form-characteristics, artistic quality or historical development of literary types, or individual great writers. Courses 12, 13A, 14A, 15A and 16 are offered in 1916–17; courses 11A, 12, 13B, 14B, 15B and 16 are offered in 1915–16 and 1917–18.]

11. English Writers and Thought. — A. *From Milton to Pope* (fall of 1915, 1917). — A survey course. It begins with a brief review of the Elizabethan period, and then considers the period of Milton (Caroline literature — Puritanism, the civil wars, Cromwell and the Protectorate), followed by the rapidly changing political and social conditions of the Restoration and then of the Revolution, ending with the Augustan age and Pope, and the temporary predominance of classicism and the intellectual instead of emotional qualities in literature. It will, however, emphasize the leading writers of the periods, including Bacon, Milton, Dryden, Addison and the essayists, Swift and Pope. Much of the literature of these times is closely associated with interesting and most important events in English political, religious and social history that introduce and explain the later modern periods. Juniors and seniors; every second year; 3 hours. [Not given in 1915–16.] Credit, 3.

Assistant Professor Smith.

B. [Withheld.]

12. AMERICAN WRITERS AND THOUGHT. — Intended to give a general survey of literature in America, especially in the nineteenth century, with an introduction to the work of the best-known writers, and with especial attention to the relations between national life and history and national thought as expressed in literature. The usual authors — Irving, Cooper, Bryant, Poe, Longfellow, Emerson, Hawthorne, Whittier, Parkman, Lowell, Holmes, Whitman, Lanier — will be discussed, and attention will be given to southern and western authors. Present writers and tendencies will also receive notice. Juniors and seniors; 3 hours. [Omitted, 1915-16.] Credit, 3.

Assistant Professor PRINCE.

13. ENGLISH WRITERS AND THOUGHT. — A. *Verse from 1744 to 1832* (fall of 1914, 1916). — A course in history, appreciation and understanding. Between the years named we see the rapid decline in formalism and a rapid increase of originality, freedom and emotional quality in literature (romanticism), accompanying the appearance in England of liberalism, industrial development, more general education and the spread of the ideals of democracy, and influenced also by Continental thought, especially the spirit of the French Revolution. This is the time in which England entered definitely upon that period of modern struggle, change and reorganization which is to be seen still continuing in contemporary affairs. Some of the writers belonging to it are Thomson, Collins, Gray and Cowper, Goldsmith, Chatterton, Blake, Crabbe, Burns, Coleridge, Wordsworth, Keats, Shelley, Scott and Byron. Juniors and seniors; alternates with Course B; 3 hours. Credit, 3.

Assistant Professor SMITH.

B. *Prose from 1744 to 1832* (fall of 1915, 1917). — A course in English prose paralleling Course A, which see. Some of the writers belonging to the period are Johnson, Sterne, Goldsmith, Burke, Miss Burney, Coleridge, Landor, Lamb, De Quincey and Hazlitt. The political essayists and the reviews will receive attention, but prose writers whose principal work was done in the novel will not be emphasized (see Course 15). Juniors and seniors; alternates with Course A; 3 hours. [Not given in 1915-16.] Credit, 3.

Assistant Professor SMITH.

14. ENGLISH WRITERS AND THOUGHT. — A. *Nineteenth Century Verse* (spring of 1915, 1917). — In general conception this course is like Course 13, which see. It begins with literature under the economic and social conditions of Victorian England, involving the advance of democracy, the spread of knowledge and culture, the advance of science, and the increase of industrialism, accompanied somewhat by materialism. The literature of the period takes new forms and directions; among its characteristics is an earnest endeavor to interpret ideals to a vastly increased and incompletely prepared reading public ("social service"). Tennyson, Browning, Mrs. Browning, Arnold, the Rossettis and Morris, Swinburne and Clough are among its noteworthy authors. Contemporary verse-writers will receive some notice. Juniors and seniors; alternates with Course B; 3 hours. Credit, 3.

Professor LEWIS.

B. *Nineteenth Century Prose* (spring of 1916, 1918). — This course parallels Course A, which see. Among the writers discussed will be Macaulay, Carlyle, Ruskin, Newman, historians (*e.g.*, Froude) and essayists (*e.g.*, Pater, Arnold and Symonds). Fiction writers are given little attention (see Course 15), but contemporary writers of other prose will be given some notice. Juniors and seniors; alternates with Course A; 3 hours. Credit, 3. Professor LEWIS.

15. PROSE FICTION. — A. *The Novel* (fall of 1914, 1916). — Readings, references, reports and class-room talks. The course is mainly informal. Among the results that may follow the study of the novel are: (*a*) a sense of critical method, springing from the consideration of historical development and of types; (*b*) a deepened humanism, consequent on the study of acts and motives of men and the influences that modify them; (*c*) increased appreciation of artistic method and form; and (*d*) acquaintance with a kind of literature that has grown into great importance through the popularizing of science, the downward extension of learning, and the democratizing of society. Juniors and seniors; alternates with Course B. Credit, 3. Associate Professor NEAL.

B. *The Short Story* (fall of 1915, 1917). — Readings, references, reports and class-room talks. The course is mainly informal. General texts, Neal's "Short Stories in the Making" and "To-day's Short Stories Analyzed." Particular results that may be obtained from short-story study are: (*a*) self-culture, the short story being well adapted to stimulate the literary, dramatic and imaginative faculties; and (*b*) acquaintance with that type in which American literature has especially succeeded. Juniors and seniors; alternates with Course A. Credit, 3. Associate Professor NEAL.

16. THE DRAMA AND SHAKSPERE. — The source, technique and development of drama, accompanied by a study of Shakspere, his mind, manner and technique. The minor Elizabethan dramatists, their influence on Shakspere, and Shakspere's influence on later writers, will be considered, as will the English social and industrial conditions of the time, their causes and their influence on Shakspere and his fellow writers. Extensive reading, analysis and interpretation of his comedies, tragedies and histories, and of modern dramatists is included. Juniors and seniors; every year; 3 hours. Credit, 3.
Assistant Professor SMITH.

RURAL JOURNALISM.

[The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the non-urban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. As practical work, members of the classes supply "The Bay State Ruralist," a feature page for the "Springfield Sunday Union." Members of all classes, except in Courses 1, 2 and 5, are subject to the following requirements: (1) preparation of all copy in typewriting in the news room (laboratory); (2) recopying in corrected form of copy after editing, or rewriting of stories under direction; (3) reading regularly of a daily newspaper and of a weekly periodical; (4) turning in weekly a specified number of suggestions for news stories or other articles.]

Elective Courses.

1. FOUNDATIONS OF WRITING: EXPOSITION. — Advanced composition; planning expository thought; expository structure; analysis of specimens, including contemporary articles from farm and rural life publications, bulletins,

etc.; some bulletin writing, including presentation of technical information for nontechnical readers. Juniors and seniors. Credit, 3.
Assistant Professor Prince.

2. Foundations of Writing: Narration and Description. — The fundamental elements of style, word-choice, diction, sentence form and paragraph types. Description of persons, places, objects, industries and productional processes, the temper and characteristic aspects of public gatherings, moods, behavior and character-sketching. Narration of incident, sustained action, events in series and the like, as in biography, dramatic situation, history and fiction. Juniors and seniors. Credit, 3. Associate Professor Neal.

3. News-gathering and News-writing. — The foundation aims and conceptions of journalism. Readings, lectures, quizzes and personal conferences; reporting on runs and on assignment; regular reading of a daily paper and of a weekly review or farm journal, with reports thereon. The central purpose is to develop ability to pick out essentials from inessentials, perceive elements of interest, and present facts with appeal to the reader. (Further practice is provided in Courses 9 and 10.) Though given somewhat informally, the year's work will bring before the student such subjects as these: City and rural newspapers, class and trade journals, reviews, magazines. Journalistic style. Nature, classes and tests of news. News values. Form of the news story; lead and feature. Stories not primarily news; feature and human-interest stories, etc. News sources; runs, assignments, correspondents. News in the home community; farm reporting; employment of news to develop home interests. This course and Course 4 are recommended to students whose vocation will require the popular presentation of technical or other information; *e.g.*, extension workers, county agents, agricultural school instructors, experiment-station editors, survey and other social service workers, men engaged in sociological or economic investigations, landscape architects, and civil and sanitary engineers. Students desiring practice in the writing of special, magazine and feature articles might find this course adapted to their purpose. Juniors and seniors. Credit, 2.[1]
Associate Professor Neal.

4. News-gathering and News-writing. — As outlined under Course 3, except that students who have taken Course 3 will be assigned different readings and may be given a larger amount of reporting or other writing.

5. Desk Editing. — A technical course for men professionally interested in journalism. Revision and rewriting; writing from another's notes; copy-reading, proof-reading, headline writing. Laboratory course. Seniors and juniors. Credit, 1. Associate Professor Neal.

7. Editorial Materials and Methods. — Readings, quizzes, reports and personal conferences; regular reading of one daily paper and one weekly review or rural life periodical; writing of editorial articles; current events.[2]

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[1] It is proposed to make this a 3-credit course after 1915–16.

[2] The addition of readings to afford an outline of recent modern history is proposed. It would add 1 to the number of credits.

Though given somewhat informally, the year's work will bring before the student such subjects as these: Editing as interpretation and as executive direction; the urban, the agricultural and the rural editor; relation of the editor to his community; editorial organization. The business side of editing. The newspaper as a public utility; its relations to community welfare. Editorial subjects and writing; sources of information; rural topics and their interpretation. Recommended to non-majoring students who desire practice in discovering the significant aspects of matters of public attention and in effectively expressing thought thereon. Laboratory course. Seniors and juniors. Credit, 2. Associate Professor NEAL.

8. EDITORIAL MATERIALS AND METHODS. — As outlined under Course 7.

9, 10. ADVANCED JOURNALISTIC PRACTICE. — Preparation, editing and publication of a rural life page or periodical. Members of the class are expected to make several trips to "The Springfield Union" offices on days when "The Bay State Ruralist" page is making up, and individual students may sometimes be placed in charge of the make-up. Recommended (like Courses 3 and 4) to students interested in writing special, magazine and feature articles. Primarily a senior course. Credit, 3.[1] Associate Professor NEAL.

PUBLIC SPEAKING.

Required Courses.

1, 2. FRESHMAN PUBLIC SPEAKING. — Freshman public speaking is required in either the first or the second semester at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Some attention is given to breath control and development of speaking voice, considerable attention to pronunciation and enunciation, and a large amount of attention to the preparation and delivery of extempore speeches. Text-book, Shurter's "Extempore Speaking," supplemented by lectures and discussions. Freshmen; in semester 1 or 2 as directed; 1 hour. Credit, 1.
Assistant Professor PRINCE and Mr. RAND.

Elective Courses.

7. DEBATING. — Considerable time is given to the study of argumentation and brief-drawing. The class is divided into teams for the platform discussion of leading questions of the day. This course is designed to develop readiness in extempore speaking. It is recommended for those who desire to enter the intercollegiate debates. Prerequisite, Course 2. Two hours. Credit, 2. Assistant Professor SMITH.

8. OCCASIONAL ORATORY. — Exercises for voice and gesture; a study of the elements of vocal expression and action; speeches on assigned topics; prescribed reading; the preparation and delivery of a formal oration or two. It is especially recommended for those who desire to enter the Flint contest. Two hours. Credit, 2. Assistant Professor SMITH.

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[1] An increase of credits to 4 is proposed for next year.

FRENCH AND SPANISH.

Associate Professor Mackimmie, Mr. Harmount.

French.

Required Courses.

1, 2. Elementary French. — The essentials of grammar are rapidly taught, and will be followed by as much reading as is possible. This course is required of freshmen presenting German for entrance who do not continue that language and have not studied French; open upon arrangement to other students. Freshmen; 4 hours. Credit, 4. Mr. Harmount.

3. Intermediate French (third year). — Training for rapid reading; the reading of a number of short stories, novels and plays; composition; reports on collateral reading from periodicals and scientific texts in the library. Required of freshmen who present two years of French for entrance and do not take German, and of sophomores who take Courses 1 and 2 as freshmen; open upon arrangement to other students; 4 hours. Credit, 4.
Associate Professor Mackimmie and Mr. Harmount.

4. Intermediate French. — As stated under Course 3, but not required of sophomores who take Courses 1 and 2 as freshmen. Prerequisite, Course 3.
Associate Professor Mackimmie.

5. Advanced French (fourth year). — A reading course; Balzac's "Eugenie Grandet" and "Le Père Goriot" and other masterpieces of the nineteenth century; Brunetière's "Honoré de Balzac" and Harper's "Masters of French Literature;" readings in the library and written reports. Required of sophomores who take Courses 3 and 4 as freshmen; open upon arrangement to other students. Prerequisite, Course 4. Three hours. Credit, 3. Associate Professor Mackimmie and Mr. Harmount.

Elective Courses.

6. Advanced French (fourth year). — A general view of the history of French literature; Kastner and Atkins' "History of French Literature." Several plays of the great classical dramatists will be read. Individual conferences on outside reading selected by the student. Prerequisite, Course 5. Sophomores; open upon arrangement to other students; 3 hours. Credit, 3.
Associate Professor Mackimmie.

7, 8. Scientific French. — This course is planned to meet the requirements of the individual student and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read. Three hours. Credit, 3. Mr. Harmount.

9, 10. Modern French Literature. — The outline is intended as a suggestion. The exact subject-matter of the course will be determined when the men are enrolled The object of this course is to give an introduction

to recent movements in French literature. In the drama, readings from Augier, A. Dumas, fils, Delavigne; in the novel, from Flaubert, the de Goncourts, Zola; in criticism, from Taine, Renan, Sainte-Beuve; for the literary history of the period Lanson's "Histoire de la Litterature Française." Prerequisite, the required French. Juniors or seniors; 3 hours. Credit, 3.
Associate Professor MACKIMMIE.

SPANISH.

Elective Courses.

1, 2. ELEMENTARY SPANISH. — Grammar, with special drill in pronunciation; exercises in conversation and composition. Reading from a reader and selected short stories. Intended primarily for juniors; open to other students upon arrangement; both semesters; 3 hours. Credit, 3.
Associate Professor MACKIMMIE.

3, 4. MODERN SPANISH AUTHORS. — Reading from modern Spanish novel and drama. Translation of English into Spanish. Private reading. Prerequisites, Courses 1 and 2. Intended primarily for seniors; 3 hours. Credit, 3.
Associate Professor MACKIMMIE.

GERMAN AND MUSIC.

Associate Professor ASHLEY, Mr. JULIAN.

GERMAN.

Required Courses.

1. ELEMENTARY GERMAN. — Grammar and composition; the reading of short stories, poems, plays, etc. Especial attention is given to oral questioning and answering in German, and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German. Arranged for freshmen; open by permission to other students; 4 hours. Credit, 4. Mr. JULIAN.

2. ELEMENTARY GERMAN. — As stated under Course 1. Prerequisite, Course 1.

3. INTERMEDIATE GERMAN. — Rapid reading of selected works from Schiller, Goethe, Lessing and others; review of grammar and dictation in German; outside readings. Required of freshmen who present German for entrance and do not take French. Freshmen; open upon arrangement to other students; 4 hours. Credit, 4. Associate Professor ASHLEY.

3A. INTERMEDIATE GERMAN. — Rapid reading of prose works, such as Sudermann's "Frau Sorge," and dramas, such as "Wilhelm Tell" and "Die Journalisten." Required of sophomores who took Courses 1 and 2 as freshmen. Mr. JULIAN.

4. INTERMEDIATE GERMAN. — As stated under Course 3. Prerequisite, Course 3.

4A. INTERMEDIATE GERMAN. — As stated under Course 3A. Open to students who have completed German 3A; 3 hours. Credit, 3.

5. ADVANCED GERMAN. — Literary study of the classicists, — Schiller's "Wallenstein," Lessing's "Nathan der Weise," Goethe's "Iphigenia," etc.; collateral readings in German and class-room reports. Prerequisite, Course 4. Sophomores; required of those who took German 3 and 4 as freshmen; open upon arrangement to other students; 3 hours. Credit, 3.
Associate Professor ASHLEY.

Elective Courses.

6. ADVANCED GERMAN. — As stated under Course 5. Sophomores; open upon arrangement to other students. Prerequisite, Course 5. Three hours. Credit, 3. Associate Professor ASHLEY.

7. SCIENTIFIC GERMAN. — Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students. Open to juniors who have completed Course 4A or more advanced work; 3 hours. Credit, 3. Associate Professor ASHLEY.

8. SCIENTIFIC GERMAN. — As stated under Course 7.

9. CONVERSATION AND COMPOSITION. — Translating connected English into German. Reproducing outside readings in German orally in class. One hour. Credit, 1. Associate Professor ASHLEY.

10. MODERN GERMAN. — As stated under Course 9.

11. GERMAN LITERATURE. — Advanced language and literary study. Conducted entirely in German. Lectures on German literature and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust," and one modern typical drama. Prerequisite, Course 6 or 10. Three hours. Credit, 3. Associate Professor ASHLEY.

12. GERMAN LITERATURE. — As stated under Course 11.

MUSIC.

Elective Courses.

1. HISTORY AND INTERPRETATION OF MUSIC. — History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school — Bach, Händel, Haydn, Gluck and Mozart. One hour. Credit, 1. Associate Professor ASHLEY.

2. HISTORY AND INTERPRETATION OF MUSIC. — A continuation of Course 1. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers. One hour. Credit, 1.
Associate Professor ASHLEY.

DIVISION OF RURAL SOCIAL SCIENCE.

President Butterfield.

AGRICULTURAL ECONOMICS.

Professor Cance, Mr. Read, Mr. Strand.

Required Course.

2. Agricultural Industry and Resources. — A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions. Sophomores; 3 hours. Credit, 3. Professor Cance, Mr. Read and Mr. Strand.

Elective Courses.

3. Elements of Agricultural Economics. — This course is designed to follow the required work in the elements of economics. It deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; determination of price; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work; 3 hours. Credit, 3. Professor Cance.

5. Historical and Comparative Agriculture. — Recommended to students in journalism or education. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work. Seniors and juniors; open to other students upon arrangement; prerequisite, Course 3 or equivalent; 3 hours. [Not given in 1915–16.] Credit, 3.
Mr. Strand.

6. Co-operation in Agriculture. — The course treats of the history, principles and business relations of agricultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements; (2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, with particular

reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises; 3 hours. Credit, 3. Professor CANCE.

7. THE AGRICULTURAL MARKET. — A study of the forces and conditions which determine the prices of farm products, and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market and direct sales are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work. Juniors, seniors and graduate students; 3 hours. Credit, 3. Professor CANCE.

8. PROBLEMS IN AGRICULTURAL ECONOMICS. — An advanced course for students desirous of studying more intensively some of the economic problems affecting the farmer. Some of these are: land problems — land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems — cost of producing farm products, farm labor in New England, immigration, agricultural credit. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest. Graduate students, seniors and juniors; open to others on approval; 3 hours. Credit, 3. Professor CANCE.

9. SEMINAR. — Research in agricultural economics and history: New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged. Credit, 1. Professor CANCE.

10. SEMINAR. — As stated in Course 9.

11. TRANSPORTATION OF AGRICULTURAL PRODUCTS. — This course will sketch the development of the transportation in the United States, covering highways, waterways, railways and electric ways with reference to the facilities for and cost of transporting farm products, opening up new agricultural areas or industries, and contributing to the wealth and welfare of the agricultural population. Lectures, text and field work. Juniors, seniors, graduate students, and others on approval; 3 hours. Credit, 3. Professor CANCE.

AGRICULTURAL EDUCATION.

Professor HART.

Elective Courses.

1. RURAL SCHOOL PROBLEMS. — Primarily for teachers. A study of agricultural education; the theory and practice of teaching; rural school organization; methods of instruction; the place and function of agriculture in the course of study for both rural and city schools; planning and practical work in school and home gardens; planning of equipment and ornamentation of rural school grounds. One lecture period, and 2 2-hour laboratory periods. Credit, 3. Professor HART.

2. As stated under Course 1.

3. Meaning of Education (Psychology). — For teachers and others desiring an introduction to mental science. A study of the development, structure and functions of the nervous system and the sense organs; the development and nature of mental activities; the nature of the learning processes. Three lecture periods. Credit, 3. Professor Hart.

4. History and Philosophy of Education. — For teachers and others desiring an introduction to educational theories. A study of educational ideals and movements as exemplified by leading nations and races; the growth of educational institutions as influenced by science and industry; the history and meaning of industrial and agricultural education. Three lecture periods. Credit, 3. Professor Hart.

5. Problems in Rural Education. — For teachers or others interested in special phases of education, such as child development, physical and mental; school organization; rural schools; secondary schools; school programs; grading and promotion of pupils; school grounds and school architecture and equipment; normal schools and the preparation of teachers; agricultural teaching and agricultural schools. Two lecture periods. Credit, 2. Professor Hart.

6. As stated under Course 5.

7. Graduate Courses. — See Graduate School.

9. Extension and County Agent Work. — The course consists chiefly of library research work. Each student will be required to produce one or more complete lectures under guidance both as to method of preparation and subject-matter, and one or more demonstrations. These lectures will be presented to public audiences in the presence of a board of critics. Some instruction will be given in organization and administration of the Extension Service. The Extension Service will be responsible for the public presentation and criticism. The student's major adviser will be responsible for the accuracy of the subject-matter. The Department of Agricultural Education will be responsible for the preparation of the lectures. One lecture and two laboratory periods. Credit, 3. Professor Hart.

10. As stated in Course 9.

RURAL SOCIOLOGY.

Professor Phelan, President Butterfield, Professor Hart, Miss Goessmann, Mr. Lund, Mr. Baird.

Elective Courses.

1. Elements of Rural Sociology. — A broad survey of the field of rural sociology, including such topics as the origin of rural sociology, its methods and problems; relation of sociological to the scientific and technical aspects of agricultural problems; the development of the rural community in New England and the west, religious, educational and social ideals of rural people; characteristics and influence of the rural environment, the movement of the rural population, the effects of immigration; rural institutions, the school, the church, local government, effects of modern conditions of life on rural in-

stitutions; rural organization; problems of progress, an analysis of the needs of rural life in its further development. To be required of sophomores after 1915–16. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3. Professor PHELAN.

2. RURAL ORGANIZATION. — A study of the organized agencies by which rural communities carry on their various forms of associated life, particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment; principles underlying leadership, qualifications of the paid leader and the lay leader; the field of rural social service, national, State and local, preparation and opportunity for service; rural community building, a study of organized ways and means by which aid is given local communities. Three hours. Credit, 3.
President BUTTERFIELD.

3. THE LITERATURE OF RURAL LIFE. — A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities. Three hours. Credit, 3. Miss GOESSMANN.

4. RURAL AND BUSINESS LAW. — The work of this course will cover such points as land, titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures and class discussions; 3 hours. Credit, 3. Professor HART.

5. RURAL GOVERNMENT. — A general survey of the development of rural government in the United States; origin of the New England town, its influence upon the west, advantages, development of efficiency, county government, the influence of the farmer in legislation, good roads movement, credit, facilities, taxation, boards of agriculture, agricultural colleges and experiment stations in relation to rural welfare; national government; a general survey of political organizations and movements among farmers in the United States and foreign countries and their influence in shaping legislation; relation of the Department of Agriculture, postal system, the various national commissions and agencies to rural welfare. Lectures, readings, written exercises on assigned topics; 3 hours. Credit, 3. Professor PHELAN.

6. FIELD WORK IN RURAL SOCIOLOGY. — This course is designed to meet the needs of students who wish to do some constructive work in rural social service while still in college. The work will be carried on in co-operation with the various college agencies engaged in rural service. Any project for which credit in this course is to be asked must first have the approval of the head of the department. Prerequisites, Courses 1 and 2. Credit, 1 to 3 hours, according to project. ————————

7. THE SOCIAL PSYCHOLOGY OF RURAL LIFE. — Characteristics of the rural mind; character of hereditary and environmental influences; nature and effects of face-to-face groups; psychological effects of isolation, relative secur-

ity and freedom from strain; relation of contact with nature, of control over immediate environment, of family co-operation and of neighborhood life to self-control, self-expression, sympathy, service and leadership; nature and effects of fashion, conventionality and custom; character of discussion and public opinion, and their relation to class feeling and organization; relation of individualism, conservatism and homogeneity to crowd phenomena and progressive democracy. Three hours. Credit, 3. Professor PHELAN.

8. RURAL SOCIAL SURVEYS. — A careful study of the theory and function of statistics, the limitations and difficulties in the use of statistics, the interpretation of statistical data, various methods of graphic representation; a study of surveys, kinds and use, method of gaining information, the basis for conclusions, value of information gained. Text and lectures; 3 hours. Credit, 3. Professor PHELAN.

10. FARMERS' ORGANIZATIONS. — The history, purposes and achievements of the Grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the method, scope and history of local, State and national associations formed about some farm product, their influence in forming class consciousness and in shaping agrarian legislation; need of federation. Lectures, readings and essays on assigned topics; 3 hours. Credit, 3.

Professor PHELAN.

11. SEMINAR.

12. SEMINAR.

GENERAL DEPARTMENTS.

MILITARY SCIENCE AND TACTICS.

First Lieutenant H. W. Fleet, 19th Infantry, U. S. A.; Assistant: Ordnance Sergeant J. J. Lee, U. S. A., retired; Adjutant Assistant: Quartermaster Sergeant Alex. Smart, U. S. A., retired.

[The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement: —

All candidates for a degree in a four-year course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical (drill) courses in military science are given up to the Christmas recess and from the close of the spring recess to the end of the semester each year; the corresponding courses in physical education occupy the intervening time.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offenses of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

The required uniform is of olive drab cloth, costing about $17. It is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $17 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.]

Required Courses.

1. Freshman Drill. — Practical instruction in infantry drill regulations through the battalion. Ceremonies. First semester until Christmas recess; 3 hours. Credit, 1. Lieutenant Fleet.

2. Freshman Drill. — As stated under Course 1. Company training in bayonet exercises and physical exercises with and without arms; 3 hours. Credit, 1. Lieutenant Fleet.

3. Freshman Tactics. — Theoretical instruction in infantry drill regulations through the battalion and ceremonies. Lectures on military subjects and military history; 1 hour. Credit, 1. Lieutenant Fleet.

4. Freshman Tactics. — As stated under Course 3.

5. Sophomore Drill. — Practical instruction in field service regulations in the service of security and information. Corporals are appointed from this class. First semester until Christmas recess; 3 hours. Credit, 1.
Lieutenant Fleet.

6. Sophomore Drill. — As stated under Course 5; intrenching, combat.

7. Sophomore Tactics. — Theoretical instruction in map problems in security and information. Combat. Lectures on military subjects and military history; 1 hour. Credit, 1. Lieutenant Fleet.

8. Sophomore Tactics. — As stated under Course 7.

9. Junior Drill. — Practical instruction in the small arms firing regulations in target practice, estimating distances and field firing. Lieutenants and sergeants are appointed from this class. First semester until Christmas recess; 3 hours. Credit, 1. Lieutenant Fleet.

10. Junior Drill. — As stated under Course 9.

Elective Courses.

11. Senior Drill. — Conduct drills of lower classes. Field officers and captains are appointed from this class. These officers are paid. The positions in every case are obtained by competition. It is to be understood that cadets obtaining these positions will be reported to the Adjutant-General of the army as distinguished cadets. First semester until Christmas recess; 3 hours. Credit, 1. Lieutenant Fleet.

12. Senior Drill. — As stated under Course 11.

PHYSICAL EDUCATION AND HYGIENE.

Associate Professor Hicks, Mr. Gore, Mr. Fitzmaurice.

Hygiene.

Required Course.

1. Hygiene. — Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation. Freshmen; 1 hour. Credit, 1.
Associate Professor Hicks.

Physical Education.

[The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in military science. All classified undergraduate students are given a physical examination upon entering.]

Required Courses.

1. Elementary Gymnastics. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 2. Freshmen; 3 hours. Credit (given only for Course 2), 1. Mr. Gore and Mr. Fitzmaurice.

2. ELEMENTARY GYMNASTICS. — As stated under Course 1.

3. GRADED GYMNASTICS. — Exercises, games and athletics; from January 1 to April 1, in connection with Course 4. Sophomores; 3 hours. Credit (given only for Course 4), 1. Mr. GORE and Mr. FITZMAURICE.

4. GRADED GYMNASTICS. — As stated under Course 3.

5. GYMNASTICS. — Drills, games and athletics; from January 1 to April 1, in connection with Course 6. Juniors; 3 hours. Credit (given only for Course 6), 1. Mr. GORE and Mr. FITZMAURICE.

6. GYMNASTICS. — As stated under Course 5.

Elective Courses.

7. TRAINING COURSE. — History of physical education; supervision of indoor and outdoor athletic contests and games; athletic administration. Seniors; 3 hours. Credit, 1. Associate Professor HICKS.

8. TRAINING COURSE. — As stated under Course 7.

THE GRADUATE SCHOOL.

THE GRADUATE SCHOOL.

KENYON L. BUTTERFIELD, A.M., LL.D., President of the College.

CHARLES H. FERNALD, Ph.D., Honorary Director of the Graduate School.

CHARLES E. MARSHALL, Ph.D., Director of the Graduate School and Professor of Microbiology.

Graduate Staff, 1915–16: Associate Professor ANDERSON, Professor CANCE, Professor CHAMBERLAIN, Professor FERNALD, Professor FOORD, Associate Professor GORDON, Professor GRAHAM, Professor HART, Professor HASKELL, Professor LINDSEY, Mr. MORSE, Associate Professor OSMUN, Associate Professor PETERS, Professor PHELAN, Assistant Professor QUAIFE, Professor SEARS, Dr. SHAW, Professor WAUGH, Director MARSHALL, President BUTTERFIELD; Mr. WATTS, Secretary.

Graduate courses leading to the degrees of master of science and doctor of philosophy have been given for a number of years; the degrees of master of agriculture and doctor of agriculture are now granted to meet strictly professional needs. The number of requests for each of these courses is apparently increasing. In recognition of the benefits to be derived from a separate organization, a distinct graduate school has been established for the purpose of fitting graduates of this and other institutions for teaching in colleges, high schools and other public schools; for positions as government, State and experiment-station specialists in farm management, dairying, live-stock husbandry, poultry science, agronomy, landscape gardening, pomology, vegetable gardening and floriculture; for positions as bacteriologists, botanists, chemists, entomologists; and for numerous other positions requiring a great amount of scientific knowledge, training and experience.

ORGANIZATION.

The school is based upon the department as the unit, and the apprenticeship system as the most effective means of instruction. This gives to the student individuality in treatment and an intimacy with actual conditions of work and operations. Besides, each student is assigned to an advisory committee, composed of the instructor in charge of his major subject as chairman, and instructors in charge of his minor subjects as members, which directs his graduate studies. The chairmen of all these committees together constitute the graduate staff, which controls the policy of the graduate school.

ADMISSION.

Admission to the graduate school will be granted: —

1. To graduates of the Massachusetts Agricultural College.
2. To graduates of other institutions of good standing who have received a bachelor's degree substantially equivalent to that conferred by this college.

In case an applicant presents his diploma from an institution of good standing, but has not, as an undergraduate, taken as much of the subject he selects for his major as is required of undergraduates at the Massachusetts Agricultural College, he will be required to make up such parts of the undergraduate work in that subject as the professor in charge may consider necessary. He shall do this without credit toward his advanced degree.

Admission to the graduate school does not necessarily admit to candidacy for an advanced degree, — students holding a bachelor's degree being in some cases permitted to take graduate work without becoming candidates for higher degrees.

Applications for membership to the graduate school should be presented to the director of the school. Full statements of the applicant's previous training, of the graduate work desired, and of the amount and kind of work already done by him as an undergraduate should be submitted, — together with a statement whether the applicant desires to work for a degree.

Registration is required of all students taking graduate courses, the first registration being permitted only after the student has received an authorization card from the director.

NATURE, METHODS AND REQUIREMENTS OF GRADUATE WORK.

Graduate work differs from undergraduate work in its purposes and methods. The primary aims of the instructor are emphasized in an attempt to have the student adjust himself and place himself in his environment; develop the rule of self-direction and self-instruction; acquire the power of accurate reasoning; gain proficiency and skill in his selected field of study or practice; and obtain an appreciative and discriminative insight into experimentation and original research. Methods are not devised, therefore, for attractiveness, entertainment and superficial reviews, but for the creation of initiative and profound thought, thorough acquaintance with detail, independent advance and industrious habits. Careful reading, lectures, conferences, surveys, laboratory exercises and field work are some of the agencies utilized.

Candidates for the degree of master of science are required to prosecute two subjects, one of which shall be designated as a major and the other as a minor. These subjects may not be selected in the same department. An original thesis is considered a part of the major subject.

Candidates for the degree of doctor of philosophy are required to prosecute three subjects, one of which shall be designated as the major and the others as minors. No two of these subjects may be taken in the same department. An original thesis shall be considered a part of the major subject.

Candidates for the degree of master of agriculture are allowed greater privileges in the selection of subjects, but will be required to select a major and such other supporting lines of study as will be necessary properly to equip the individual professionally.

Candidates for the degree of doctor of agriculture are required to select a major and such other subjects as will develop the major in its greatest intensity and comprehensiveness. Successful experience is also requisite, together with a thesis which represents a masterly survey or intimate study through accurate application of some phase of the major subject.

Candidates for membership in the graduate school who do not desire to work for a degree may, with the approval of the director of the school, take more than one subject in the same department, or pursue work in several departments, if their preparation will permit. A statement of the subjects chosen must in each case be submitted to the director of the graduate school for approval by the student's advisory committee. The chosen subjects must bear an appropriate relation to each other.

A working knowledge of French and German is essential to successful graduate work, and students not having this will find it necessary to acquire it as soon as possible after entering.

The graduate staff reserves the privilege of recommending and allowing courses in other institutions as a part of residence instruction. Such supervision will be exercised and credit granted as are essential to the highest standards of efficiency.

THESES.

A thesis is required of each candidate for an advanced degree. It must be on a topic belonging to the candidate's major subject; must show that its writer possesses the ability to carry on original research; and must be an actual contribution to knowledge.

Two copies of each thesis in its final form, ready for the printer, must be submitted to the director of the school before the candidate for the degree may take the required oral examination. One of the said copies, to contain all drawings, is to be retained as an official copy by the said director, and the other by the department in which the thesis was prepared. The candidate for the doctor's degree must be prepared to defend at the oral examination the views presented in his thesis. When printed, three copies of each thesis must be deposited with the director of the graduate school and three copies with the department in which the work was carried out.

FINAL EXAMINATIONS.

For the degree of master of science or master of agriculture, a final examination, which may be either written or oral, or both, is given upon the completion of each subject.

For the degrees of doctor of philosophy or doctor of agriculture, final examinations on the minors taken are given upon the completion of the subjects. In the major subject, a written examination, if successfully passed, is followed by an oral examination in the presence of the faculty of the school.

DEGREES CONFERRED.

The degree of master of science and master of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least one year and a half[1] to the prosecution of study in two subjects of study and research, not less than one full college year of which must be in residence.

2. The devotion of twenty hours[1] each week to the chief or major subject, and of from twelve to sixteen hours per week to the minor subject.

3. The preparation of a thesis in the major subject, constituting an actual contribution to knowledge, and accompanied by drawings if necessary. The thesis may be waived for the degree of master of agriculture.

4. The passing of final examinations, in both major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The degrees of doctor of philosophy and doctor of agriculture are conferred upon graduate students who have met the following requirements: —

1. The devotion of at least three years to the prosecution of three subjects of study and research in residence at the college.

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[1] All time statements refer to minimum time.

2. The devotion of twenty hours[1] each week to the chief or major subject during the entire period, and of from twelve to sixteen hours per week for a year and a half to each minor subject.

3. The preparation of a thesis, in the major subject, constituting an actual contribution to knowledge and accompanied by drawings if necessary. For the degree of doctor of agriculture the thesis may be modified to meet professional requirements.

4. The passing of final examinations, in both the major and minor subjects, to the satisfaction of the professors in charge.

5. The payment of all fees and college expenses required.

The fee for the degree of master of science or master of agriculture is $10, and for the degree of doctor of philosophy or doctor of agriculture, $25.

Courses offered.

Courses available as major subjects for the degree of doctor of philosophy: —

Botany.
Chemistry.
Entomology.
Horticulture.
Microbiology.

Courses available as major subjects for the degree of master of science: —

Agriculture.
Agricultural economics.
Agricultural education.
Agronomy.
Animal husbandry.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Mathematics and physics.
Microbiology.
Poultry science.
Rural sociology.
Veterinary science.

Courses available as major subjects for the degree of master of agriculture: —

Agronomy.
Animal husbandry.
Poultry science.

Courses available as minor subjects for the degree of doctor of philosophy: —

Agriculture.
Agricultural economics.
Agricultural education.
Agronomy.
Animal husbandry.
Animal pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Microbiology.
Poultry science.
Rural sociology.
Zoölogy.

Courses available as minor subjects for the degree of master of science: —

Agriculture.
Agricultural economics.
Agricultural education.
Agronomy.
Animal husbandry.
Animal pathology.
Botany.
Chemistry.
Entomology.
Horticulture.
Landscape gardening.
Microbiology.
Mathematics and physics.
Poultry science.
Rural sociology.
Veterinary science.
Zoölogy.

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[1] All time statements refer to minimum time.

GENERAL OUTLINE OF COURSES FOR ADVANCED DEGREES.

AGRICULTURAL ECONOMICS (Major Course). — 1. Graduate research work in agricultural economics will be developed by four principal methods, namely, historical, statistical, accounting and general field investigation. In all instances the method includes facility in investigation, tabulation and interpretation of results.

2. Candidates for the master's degree, or candidates offering a minor in agricultural economics, will be required to pass an examination covering the undergraduate work now offered in agricultural economics, including Course 3, the elements of economics, Course 7, the agricultural market and Course 6, co-operation in agriculture; and in addition such definite research work as may be outlined by the department, to consist of original investigations in some particular divisions of the subject of agricultural economics. Courses 6, 7 and 8 are for graduates and undergraduates. Special investigations may be made by electing seminars in agricultural economics.

3. Candidates for the master's degree will be required to write a thesis or a report covering results of a specific line of personal investigation in one or more fields of the subject. Each candidate will also be required to have a working knowledge of the general field of economics, the theory of agricultural economics, the problems of agricultural production, land tenure, land problems, agricultural commerce, agricultural co-operation, statistics of agriculture and prices, and markets and marketing.

AGRICULTURAL EDUCATION (Major Course). — Courses are available in agricultural education as major or minor subjects for the degree of master of science, or, as a minor subject, for the degree of doctor of philosophy. Study will be pursued along one or several of the following lines: —

1. Massachusetts school legislation.
2. Origin and growth of primary, secondary and higher education in Massachusetts.
3. The origin and growth of normal schools, industrial schools and agricultural schools.
4. Educational literature, fiction, periodicals and reports.
5. The physical and mental development of the individual.
6. School administration.

AGRONOMY (Master of Science). — This course is developed in two directions, depending on whether the candidate is preparing for scientific work or for teaching. In the former case more attention is paid to methods of investigation; in the latter, to interpretation of results. The student may specialize in either Part I. or Part II. of the following: —

I. *Soil Fertility.* — (*a*) The humus problem: Effect of different cropping systems on the humous content of the soil; cultivation, drainage and liming in their effect on soil humus; increase by green manure crops; use of animal manures as sources of humus; conservation of organic matter.

(*b*) The nitrogen question: Losses of nitrogen as occasioned by cropping system, tillage methods and soil treatment; gain of nitrogen through legumes and other agencies; commercial nitrogen, physiological effect upon the plant, comparison of different forms both in regard to their ultimate as well as immediate effect, amount of application from the business standpoint.

(*c*) Mineral elements of plant food: as above for nitrogen.

(*d*) Lime: Causes of "soil acidity;" comparison of forms of lime; ultimate effect of lime on soil fertility; cost *versus* returns from use of lime.

(*e*) Crop adaptability.

II. *Field Crops.* — (*a*) Distribution, as governed by soil fertility; climatic influences; economic conditions.

(*b*) Kinds and varieties.

(*c*) Cultural methods.

(*d*) Breeding: A knowledge of the principles of breeding is presupposed. With this as a basis, a study of methods, practices and results, as applied to a given crop, must be made.

III. *Thesis.* — The thesis may be taken either in soil fertility or in crop production. In either case a problem for original investigation must be formulated by the candidate, the line of attack developed, the work carried through and results presented in acceptable form.

Literature. — It is required that the candidate familiarize himself with the available literature of the various topics studied.

ANIMAL HUSBANDRY (Master of Science). — *Course A. Animal Breeding.* — 1. Reading: Thorough survey of the scientific works dealing with plant and animal breeding and improvement.

2. Project: Each student must outline and pursue some Mendelian problem.

3. Thesis: This to be a complete treatise of the problem which the student undertakes; it should be a valuable contribution to the present knowledge of the question of animal breeding.

Course B. Animal Nutrition. — This course is in outline similar to A. It is designed to cover the field of nutrition, feeding and management of live stock.

Seminar: Regular periods will be devoted to a discussion of the projects undertaken, together with criticisms of the available material on the question pursued.

Object. — To give the student a comprehensive knowledge of feeding, breeding and management of live stock. This may be divided into a major and a minor, in order to give the student the opportunity of devoting a proportionate share of his time to the class of live stock in which he is particularly interested.

Reading. — The student is to make a very complete survey of experimental and periodical literature dealing with the various phases of the subject.

Practice. — Before the completion of the work for the degree, the student must have the equivalent of at least one year's continuous work on an approved live-stock farm.

Seminar. — Regular periods to discuss progress of the work.

ANIMAL PATHOLOGY (Minor Course only). — 1. Reviews in anatomy.

2. Reviews in organography and histology.

3. Special lectures and readings in general and special pathology.

4. Laboratory studies in general and special pathology.

5. Pathological technique.

6. Conferences.

BOTANY (Major Course). — Advanced work in botany may be taken in the following branches: —

(*a*) Plant physiology and ecology.

(*b*) Mycology.

(*c*) Plant pathology.

(*d*) Histology.
(*e*) Cytology.
(*f*) History of botany.

Particular attention is given to plant physiology and plant pathology, and students usually select for research a problem bearing on some phase of these branches of botany. It is aimed, however, to give each student a broad training in the science, and the attention which each one is required to give to other branches is determined by his previous training. Extensive reading of botanical literature is required. Lectures are given and weekly seminars are held at which important current botanical papers are reviewed and discussed.

CHEMISTRY. — I. Major course for the degree of master of science. Students will be required to take Courses 21, 28, 29, 30 and 31. In addition to this the requirements in the various thesis subjects are: —

Organic and Bio-Chemistry. — Courses 32 and either 25, 26 or 27, and 4 hours for one semester selected from Courses 23 (*b*) and (*f*), and 24.

Analytical and Agricultural Industrial Chemistry. — Courses 33, 23 (4 hours), and 4 hours for one semester selected from Courses 22, 24, 25, 26 and 27.

Physical Chemistry. — Courses 34, 24 and 4 hours for one semester selected from Courses 22, 23, 25, 26 and 27.

The candidate must pass a final written and oral examination before the Department of Chemistry upon undergraduate Courses 1 to 11, inclusive, 13 and 15, and upon all graduate work taken in chemistry by him.

II. Major course for the degree of doctor of philosophy. Students will be required to take Courses 21 to 31, and one course selected from 32, 33, 34 or 35. In addition, the student may be required to spend at least one semester at some other recognized institution pursuing graduate work in chemistry. The candidate must pass a final written examination before the Department of Chemistry, and an oral examination before the graduate staff, upon the whole field of chemistry, and must be especially well prepared in the lines of work covered by his research.

III. Minor course for the degrees of master of science and doctor of philosophy. Students will be required to take work totaling 36 to 48 hours. This may be selected from any of the undergraduate Courses 5, 6, 9 to 15, inclusive, or any of the graduate courses for which the student is prepared. In addition, the candidate must pass a final written and oral examination before the Department of Chemistry upon the courses taken and upon undergraduate Courses 5, 6, 9, 10 and 15.

The following is a list of the courses: —

21. *Inorganic Preparations.* — Laboratory. The preparation of chemical products from raw materials. The manufacture and testing of pure chemicals. The laboratory work is essentially synthetic in nature, and is designed to aid in acquiring a more adequate knowledge of inorganic chemistry than is to be obtained by chemical analysis alone. Ten to fifteen of the preparations given in Biltz's "Laboratory Methods of Inorganic Preparations" will be made by each student. First semester, 4 hours. Associate Professor ANDERSON.

22. *Advanced Inorganic Preparations.* — Laboratory. Continuation of Course 21. Either semester, 4 hours. Associate Professor ANDERSON.

23. *Advanced Analytical Chemistry.* — Laboratory. This course may be taken in part as follows: (*a*) electrolytic analysis, 4 hours per week; (*b*)

ultimate analysis, 4 hours per week; (*c*) special analytical work to meet the needs of the individual student, 4 hours per week. In addition, parts of undergraduate Courses 10 and 11 may be taken as follows: (*d*) fertilizers, 4 hours per week; (*e*) insecticides, 4 hours per week; (*f*) milk and butter, 4 hours per week. Either semester. Credit determined by amount of work done.
Professor WELLINGTON and Associate Professor PETERS.

24. *Advanced Physical Chemistry.* — Laboratory. Measurement of the electrical conductivity of solutions; degree of ionization; ionization constants; per cent. hydrolysis of aniline hydrochloride from conductivity measurements; solubility product by the conductivity method; velocity of saponification by conductivity; neutralization point by conductivity; vapor pressure determinations; critical temperature of carbon dioxide or sulphur dioxide; transport numbers; preparation and properties of colloidal solutions; transition points by dilatometric method; heat of solution of ammonium chloride and potassium nitrate; adsorption of iodine by charcoal; splitting of racemic glycerinic or racemic tartaric acids into their optical components. To each student separate work will be assigned. Either semester, 4 hours.
Associate Professor ANDERSON.

25. *Advanced Organic Preparations.* — Laboratory. The preparation of compounds not included in Courses 5 and 6, such as the Kolbe synthesis of salicylic acid; benzophenone and Beckmann's rearrangement; rosaniline, malachite green, congo red, indigo and other dyes; synthesis of fructose; Grignard reaction. Barnett, Cain and Thorpe, Gatterman, Noyes, Fischer and other laboratory guides are used. To each student separate work will be assigned. Either semester, 4 hours. Professor CHAMBERLAIN.

26. *Advanced Bio-Chemistry.* — Laboratory. The hydrolysis of proteins and isolation of the amino acids; the study of milk, blood and urine; dietary and digestion studies. References: Abderhalden, Plimmer, Salkowski, Hawk, etc. To each student separate work will be assigned. Either semester, 4 hours.
Professor CHAMBERLAIN.

27. *Industrial Organic Chemistry.* — Laboratory. The preparation, on a large scale, of wood alcohol, acetic acid, ethyl alcohol, benzene and cellulose products, such as mercerized cotton and artificial silk. References: Molinari, Rodgers and Aubert, Thorpe, Enzyklopädie der tech. Chemie, etc. To each student separate work will be assigned. Either semester, 4 hours.
Professor CHAMBERLAIN.

28. *Advanced Theoretical and Analytical Chemistry.* — Lectures. The following are among the topics considered: compressibility of the atoms; atomic structure; valence electrons; and detailed studies of substances important in analytical chemistry, such as barium sulfate, silver chloride, magnesium pyrophosphate. Second semester, 1 hour. Associate Professor PETERS.

29. *Advanced Organic and Bio-Chemistry.* — Lectures. Selections from the following topics: the constitution, chemical relationship, physiological function and industrial uses of fats, cholesterol, phytosterol, lecithin, carbohydrates, proteins, amino acids, urea, uric acid, purine bases, alkaloids, terpenes, tannin,

essential oils, synthetic dyes, rubber; the study of enzymes, fermentation, animal food and nutrition, photosynthesis; isomerism, tautomerism, condensation. References: Monographs on Bio-Chemistry, Chemical Monographs, Abderhalden, Plimmer, Haas and Hill, Lewkowitsch, Cohen, Fischer, Euler, Czapek, Cain and Thorpe. First semester, 1 hour.
Professor CHAMBERLAIN.

30. *Advanced Theoretical and Physical Chemistry.* — Lectures. The relation between the constitution and properties of compounds; mutarotation; steric hindrance; stereoisomerism of other elements than carbon; molecular association; similarity between compounds of silicon and carbon; radioactivity. Second semester, 1 hour. Associate Professor ANDERSON.

31. *Seminar.* — Conferences, reports or lectures. Both semesters, twice a month, 1 hour. Professor LINDSEY.

32. *Research in Organic and Bio-Chemistry.* — Both semesters. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done. Professor CHAMBERLAIN.

33. *Research in Analytical or Agricultural Industrial Chemistry.* — Both semesters. A minimum of 20 hours' laboratory work per week. Credit determined by the amount of work done.
Professor WELLINGTON and Associate Professor PETERS.

34. *Research in Physical Chemistry.* — Both semesters. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done.
Associate Professor ANDERSON.

35. *Research in Agricultural Chemistry.* — Both semesters. A minimum of 20 hours' laboratory work per week. Credit determined by amount of work done. Professor LINDSEY and EXPERIMENT STATION ASSOCIATES.

ENTOMOLOGY (Major Course). — I. For the degree of doctor of philosophy as a major: Some knowledge of all the divisions of this subject is essential for the professional entomologist, though a large part of his time will be devoted only to certain portions. To insure some familiarity with all these divisions, lectures, laboratory work, field training or required reading are given in each of the following topics: —

(*a*) *Morphology.* — Embryology and polyembryony; transformations; histology; phylogeny; hermaphroditism; hybrids; parthenogenesis; pedogenesis; heterogamy; chemistry of colors; coloration; luminosity; deformities; variation.

(*b*) *Ecology.* — Dimorphism; polymorphism; protective devices; mimicry; psychoses; insect architecture; plant fertilization; insect products; geographical distribution; methods of distribution; migration; geological history; insects and disease; enemies of insects, vegetable and animal; duration of life; experimental entomology.

(*c*) *Economic Entomology.* — Special methods of control; insecticides; special research; insect photography; methods of preparing illustrations;

field work and life-history investigations; insect legislation; methods of record keeping.

(*d*) *Systematic Entomology.* — History of entomology; classifications and the principles of classification; nomenclature and its rules; how to find and use literature; preparing indices; number of insects known and in existence; lives of prominent entomologists; methods of collecting, preparing, preserving and shipping; important collections; location of types.

(*e*) *Seminar.* — A monthly meeting of graduates, at which reports on current literature are presented and various entomological topics of importance are discussed.

(*f*) *Required Readings.* — The best articles on topics named above and on the different orders of insects, in English, French or German, the candidate to be examined at the close of his course on this with his other work.

(*g*) *Thesis.* — A thesis, illustrated with drawings, consisting of the results of original investigation upon one or several topics, and constituting a distinct contribution to knowledge, must be completed before the final examinations are taken.

II. For the degree of doctor of philosophy as a minor, and for the degree of master of science either as a major or minor: Such portions of the course outlined above as seem most appropriate to their other subjects are given to students taking entomology as a minor.

HORTICULTURE. — Graduate work is offered in various lines of horticulture. For the most part this is divided into the different departments which now constitute the college Division of Horticulture, as follows: pomology, floriculture, landscape gardening, forestry and market gardening. For work in these lines application should be made direct to the heads of the several departments.

Besides this work, however, opportunity is offered for graduate study in general horticulture, including topics from the several organized departments mentioned, and also questions relating to plant breeding, general evolution, propagation, manufacture of horticultural products, etc. This general work is under the direction of Prof. F. A. Waugh, head of the Division of Horticulture.

LANDSCAPE GARDENING (Major Course). — Every student before receiving his master's degree with a major in landscape gardening must have given some thorough and fruitful study to each of the following five departments. As far as possible these studies must be of a practical nature, *i.e.*, they must be made upon actual projects in progress of development.

1. *Theory.* — The principles of esthetics as applied to landscape gardening.
2. *Design.* — The principles of pure design and their application in landscape and garden planning.
3. *Construction.* — The practical methods of carrying out landscape plans, laying out, equipment, organization of working force, time and cost keeping, etc.
4. *Maintenance.* — Methods, organization, cost.
5. *Practice.* — Office work, drafting, estimating, reporting, charges, accounting.

Qualifications. — Each student before he may receive the master's degree with a major in this department must convince his instructors that he has a genuine aptitude for some branch of landscape gardening, either in design, construction or management.

Thesis or Project. — Each student, before receiving the master's degree with a major in landscape gardening, must present a satisfactory thesis or complete project. A thesis will consist of a careful original study of some problem in landscape gardening, presented in typewritten form with any necessary illustrations, such as photographs, diagrams, drawings, etc. A project will consist of a completed set of studies of some suitable landscape-gardening problem, such as the design of a park, a real estate subdivision, an extensive playground. Such a project will usually consist of: —

(*a*) Original surveys, including topography.
(*b*) Block plans, showing original design.
(*c*) A rendered plan or plans of the main features.
(*d*) Detailed working drawings.
(*e*) Estimates of cost.
(*f*) Complete report and letter of transmittal.

Minor Course. — Any student electing a minor in landscape gardening will be directed to take such courses from the regular catalogue list as may seem most suitable for him. Under ordinary circumstances no other work will be given to students electing minors. In special cases, however, individual problems will be assigned and individual instruction given. These exceptions will be made in cases where, by so doing, it is possible to give the student material assistance in the plan of his major work.

MICROBIOLOGY (Major Course). — 1. *Reading.* — Readings will be assigned and reports with critical analyses of literature covering the general subject will be required. For this purpose such material will be selected as will be most pertinent to the needs of the student. Lectures will be given from time to time.

2. *Seminar.* — At intervals the immediate laboratory work and studies of the student will be surveyed and the literature bearing thereon will be discussed. The shaping of investigations in accordance with the critical analyses of the specific literature of the problem involved will be the important rôle of the seminar.

3. *Morphological and Cultural Studies.* — Special advanced studies in the cytology, morphology and cultural characters of micro-organisms will be the general theme of this course. The important factors in classifying and grouping organisms call for an intimate knowledge of this particular phase of microbiology. Laboratory technic will receive emphasis.

4. *Physiological Studies.* — The changes produced by micro-organisms and their functionings in general open a very broad field for investigation and systematic study. It is advised that every graduate student in microbiology give much attention to this branch, gaining thereby the greatest comprehensive knowledge of physiological processes, as well as the methods employed in their determinations.

5. Special advanced courses will be offered in those phases of microbiology indicated by the undergraduate courses: —

1. Fermentation microbiology.
2. Soil microbiology.
3. Dairy microbiology.
4. Food microbiology.
5. Hygienic and sanitary microbiology.

It will be assumed that all graduate students of microbiology must be acquainted with the details of all important phases of agricultural microbiology.

Minor Course. — 1. Courses constituting undergraduate major in microbiology, or their equivalent, will be required.

NOTE. — If the student is familiar with the work of these courses, advanced work will be given in accordance with the graduate major outline.

2. Emphasis will be placed upon that particular phase of microbiology which will be particularly pertinent to the student's major course.

3. Readings will be assigned, and will be reviewed in conferences.

4. Special lectures on selected subjects in microbiology will be given from time to time.

POULTRY SCIENCE (Major Course for the Degrees of M.S. and M.Agr.). — 1. *Reading.* — This course consists of a review of the entire field of poultry literature, covering books, bulletins and special articles. A written report on one or more subjects will be required.

2. *Seminar.* — This course consists of a criticism of the most important experiments carried on at the various stations in this and other countries; also a study of poultry conditions in foreign countries, methods of management, etc., besides a detailed study of some of the largest poultry projects in this country.

3. *Anatomy (Gross and Histological), Physiology, Embryology and Surgery.* — This course consists of a careful study of the anatomy and physiology of the fowl; also the development of the chick in the shell, not only as an embryological study, but in relation to morphogenesis and heredity. Instruction in surgical technique, adapted to fowls, forms part of the work.

4. *Breeding.* — The student will carry on such breeding experiments as time and facilities permit. He may also do work in connection with our regular experimental projects. A detailed study of the pertinent literature will be required. Animal Husbandry 5, or its equivalent, is a prerequisite.

5. *Feeding.* — A study of the relation of various foods and other substances to the morphology and physiology of the bird, with special reference to such subjects as egg production, feather form and structure, condition of flesh, bone, etc.

6. *Brooding.* — Studies will be made upon the relation between viability and rate of growth and the following topics: type of brooder, number of chicks in brood, ventilation, humidity, sanitation, exercise and weather conditions; also a comparison of hen-hatched chicks with those hatched artificially.

7. *Incubation.* — This course includes a study of a large number of perplexing problems of a practical, scientific and mechanical nature.

8. *Poultry Diseases.* — This course includes a study of a number of the most important poultry diseases in relation to the rapidity with which they spread and their eradication; also various problems in poultry sanitation.

9. *Thesis.* — This may be either of a scientific or practical nature, or both, and subjects may be chosen from any one of the above courses, except the first and second. (Required of students working for degree of M.S.)

NOTE 1. The postgraduate course presupposes all undergraduate work or its equivalent, together with practical experience. Without the latter, students will be unable to handle Courses 4, 5 and 6. At the discretion of the instructor in charge, graduate students may be required to pursue undergraduate courses in other departments without credit.

NOTE 2. Practical poultry work may be required, but no credit will be given for such work.

NOTE 3. Courses 1 and 2 are designed particularly for minors.

Rural Sociology. — *General Sociology.* — Candidates for the doctorate must have a good working knowledge of general sociology.

1. History and development of sociological thought.
2. The literature of sociology.
3. Problems of modern sociology and methods of reform.

Rural Sociology. — Candidates will be required to pass an examination in all courses offered by this department primarily for undergraduates, as shown in the departmental classification.

Research Work in Rural Sociology. — Each candidate will be required to select two or more of the divisions of the subject for intensive study and research.

1. The rural community: —
    - (*a*) Historical development.
    - (*b*) Influence of modern conditions on family and community life.
    - (*c*) Problems and methods in community organization.
    - (*d*) Community planning in Massachusetts.
2. Origin and development of rural institutions: —
    - (*a*) Scope, function and influence of educational institutions on rural social progress. Plans for betterment.
    - (*b*) History of the development of the rural church, its problems and program for improvement.
    - (*c*) The farm family, in its relation to religious, cultural, educational and social agencies. The relation of the standard of living to rural social progress.
3. Rural organization: —
    - (*a*) The scope and function of rural organization in development of rural life.
    - (*b*) Work of the national government in rural organization.
    - (*c*) County and institutional work in rural organization.
    - (*d*) Leadership in its relation to organization.
4. Rural government and rural law: —
    - (*a*) Development of rural local government in New England and the west. Progress in efficient local self-government.
    - (*b*) Relation of the State to the farmer, influence of the farmer in legislation, the organized ways and means by which the State aids the farmer directly.
    - (*c*) Work of the national government in its relation to the social welfare of the farming people.
    - (*d*) Agrarian legislation in the United States and Europe affecting rural social welfare.
5. Farmers' organizations: —
    - (*a*) Social problems underlying farmers' organizations in reference to service and permanency.
    - (*b*) Principles of organization.
    - (*c*) History of farmers' organizations in the United States.
6. Rural social and sociological surveys: —
    - (*a*) An intensive study of the place and function of statistical data in the sociological field, its evaluation and interpretation.
    - (*b*) A critical study of social surveys of rural life and methods of survey, with a view to discovering the strength and weakness of each.
7. Social condition of the rural people: —
    - (*a*) Origin and development of rural ideals.
    - (*b*) The status of the rural people in relation to health, morality, crime, etc.
    - (*c*) Problems of social psychology arising in rural life.

A thesis showing the results of personal investigation on some particular topic or topics must be presented. The thesis must show familiarity with the material bearing on the subject, ability in discovering and utilizing original sources, judgment in evaluating facts, evidences and authorities, originality and independence of thought. It must be a contribution in a very definite way to rural sociological thought.

Candidates for the master's degree, or candidates offering a minor in rural sociology, will be required to pass an examination in the following courses offered by the department for undergraduates: —

Course 2. Rural organization.
Course 5. Rural government.
Course 7. Social psychology of rural life.

In addition, they will be required to pursue a line of investigation through work in the seminar.

Veterinary Science. — Work is available in anatomy, hygiene, veterinary pathology, medicine, surgery, parasitology and other special lines or divisions of the subject.

Zoölogy. — Courses in zoölogy may be available as a minor for the degree of master of science and as a minor for the degree of doctor of philosophy. The nature of the work will necessarily vary according to circumstances, and may be intensive in a special field, like that of embryology or economic ornithology, and be correlated closely with the major work of the student, or it may be of a more general character, depending on the student's needs or previous acquaintance with general zoölogical science. The time devoted to zoölogy as a minor for either of the above-named degrees may vary from 12 to 16 hours per week, pursued for a year and a half.

List of Students.

A list of the degrees conferred in the Graduate School, and of the students enrolled, is given in the general lists at the end of the volume.

THE SHORT COURSES
AND
THE EXTENSION SERVICE.

The Short Courses and the Extension Service.

SHORT COURSES.

The short courses offered by the Massachusetts Agricultural College are designed to meet the needs of those who cannot come to the college for the regular academic courses. They furnish the student with instruction in modern accepted methods, and are made as concentrated and as practical as possible. In the main, the instruction is given by the regular teaching force of the college, the same laboratories and equipment being used as in the regular college work.

The short courses may be grouped as follows: —

A. Winter Schools.
  1. Ten Weeks' Course.
  2. Farmers' Week.
  3. Annual Beekeepers' Convention.
  4. Polish Farmers' Day.
  5. Spring Beekeeping School.
  6. Apple Packing School.
  7. Annual Conference of County Agents and Vocational Agricultural Instructors.

B. Summer Schools.
  1. Summer School of Agriculture and Country Life.
  2. School for Rural Social Service.
  3. School for Library Workers.
  4. Poultry Convention.
  5. Agricultural Camps.
  6. Conference on Rural Organization.

C. Miscellaneous Short Courses.
  1. Short Courses for Special Groups (feed dealers, town officials, etc.).
  2. Special Days for Foreigners.
  3. Meetings of Organizations at the College.

Expenses of the Short Courses. — The expense of attending any of the short courses is approximately as follows: —

Registration fee (Ten Weeks' Course, Apple Packing School, Summer School),	$5
Furnished rooms in private houses (per week),	$1.50–$3
Board at college dining hall (per week),	$4–$4.25
Board with private families (per week),	$5–$6

A lunch counter is operated in connection with the college dining hall. Meals may be obtained there *à la carte* at very reasonable rates.

Students in each of the dairy courses must provide themselves with two white wash suits and caps for use in the practical dairy work. The cost in Amherst is about $1.25 for suit and cap.

Requirements for Admission to Short Courses. — No entrance examinations are required, but students are advised to review their school work in English and arithmetic. Practical experience in farm, garden, orchard or greenhouse work is an advantage. The courses are open to both men and women.

Students must be at least eighteen years of age, and must furnish satisfactory evidence of good moral character. References are required, and these are investigated before applicants are accepted.

A. WINTER SCHOOLS, 1916.

1. OUTLINE OF THE TEN WEEKS' COURSES (JANUARY 3 TO MARCH 10, INCLUSIVE). — The following courses are offered: —

1. Soil Fertility. Professor HASKELL. Three lectures a week.
2. Field Crops. Assistant Professor JONES. Two lectures and one two-hour laboratory period a week.
3. Types and Breeds of Live Stock. Professor McNUTT. Three lectures and two two-hour judging periods a week.
4. Live Stock Feeding. Assistant Professor QUAIFE. Three lectures a week.
5. Animal Breeding. Professor McNUTT. One lecture and one two-hour laboratory period a week.
6. Dairying. Professors LOCKWOOD and JAMISON, Mr. COONS and Mr. BALDINGER. Five lectures and one one-hour, two two-hour and two three-hour laboratory periods a week.
7. Dairy Bacteriology. Professor MARSHALL. Two lectures a week.
8. Animal Diseases and Stable Sanitation. Professor PAIGE. Two lectures a week.
9. Poultry Husbandry. Professor GRAHAM and Mr. PAYNE. Five lectures and one two-hour laboratory period a week.
10. Farm Management and Farm Accounts. Professor FOORD. One lecture and one two-hour laboratory period a week.
11. Fruit Growing. Professor SEARS. Three lectures and one two-hour laboratory period a week.
12. Market Gardening. Assistant Professor A. S. THOMSON. Three lectures and two two-hour laboratory periods a week.
13. Landscape Gardening. Assistant Professor HARRISON. Two two-hour periods a week.
14. Floriculture. Associate Professor NEHRLING and Mr. THURSTON. Three lectures a week; field trips on Saturday.
15. Forestry. Professor CLARK. One lecture a week.
16. Botany. Assistant Professor ANDERSON. Two lectures a week.
17. Entomology. Dr. W. S. REGAN. Three lectures a week.
18. Beekeeping. Associate Professor GATES and Mr. BYARD. Two lectures and one two-hour laboratory period a week.
19. Farm Mechanics. Professor GUNNESS. One lecture and one two-hour laboratory period a week.
20. Rural Sanitary Science. Professor MARSHALL. Two lectures a week.
21. Rural Improvement. Professor WAUGH. Two lectures a week.
22. Problems of Marketing and Distribution. Professor CANCE. Two lectures a week.

2. FARMERS' WEEK. — In order to reach those who cannot come to the college for a longer time this very practical course, five days in length, is given each year. The regular college equipment is used, and work of the regular faculty is supplemented by lectures and demonstrations by eminent men and women.

The 1916 program will probably be divided into seven sections, as follows: —

1. Field Crops and Farm Management.
2. Animal Husbandry and Dairying.
3. Poultry Husbandry.
4. Fruit Growing, Market Gardening, Floriculture, Forestry.
5. Women's Section, Home Economics.
6. Business Organization and Marketing.
7. Beekeeping.

These sections take up the time from early morning until late afternoon. Prominent men are engaged for the evening lectures. Fruit, corn, live stock, dairy and poultry shows, and other exhibits, are among the leading features. No fee is charged.

Owing to the prevalence of foot and mouth disease in 1915 the best program yet prepared was necessarily abandoned. Special efforts will be made in the preparation for the biggest Farmers' Week yet held, from March 13 to 17, inclusive, 1916.

3. ANNUAL BEEKEEPERS' CONVENTION. — This convention of beekeepers is held during Farmers' Week. Illustrated lectures, practical demonstrations and commercial displays are features of the convention. Meetings of State and county beekeepers' associations and of apiary inspectors also are scheduled at this time.

4. POLISH FARMERS' DAY. — A special day is each year set aside which is known as "Polish Farmers' Day." Instruction is given relative to the crops and animals in which the Polish people are most interested, soil fertility problems, co-operation, American citizenship, history, etc. Hundreds of Polish farmers reside in the Connecticut valley, and large numbers avail themselves of this opportunity which is peculiarly their own. It will be held on March 23, 1916.

5. SPRING BEEKEEPING SCHOOL. — This school is held in Amherst once in three years, being conducted in other sections of the State in intervening years. It is an intensive course for a limited number of beekeepers. It occupies seven hours daily for a period of two weeks. Courses are given in practical beekeeping; life of the honeybee; special problems of the beekeeper; crops foraged by bees; relation of bees to pollination of plants; bees in horticultural practice. The instructors are Professors Gates, Fernald, Paige, Brooks, Osmun, and Chenoweth and Mr. Byard. The course will be given May 31 to June 14, 1916.

6. APPLE PACKING SCHOOL. — The work of this school, which is conducted by the Department of Pomology, is of a practical nature, and includes both box and barrel packing. Persons taking the course will become familiar with the various types of packs, and will receive sufficient practice to enable them to do good commercial packing. The 1916 school will probably be held November 15 to 21, inclusive.

7. ANNUAL CONFERENCE OF COUNTY AGENTS AND VOCATIONAL AGRICULTURAL INSTRUCTORS. — In December of each year a one-week conference of county agents and vocational agricultural instructors is held at the college. This is for the purpose of correlating the extension work throughout the State, and to enable the field workers to keep in up-to-the-minute touch with agricultural problems, methods and research as conducted in Massachusetts as well as other States in this particular section of the country. The fourth annual conference will probably be held during the second full week in December, 1916.

B. SUMMER SCHOOLS.

1. THE SUMMER SCHOOL OF AGRICULTURE AND COUNTRY LIFE. — The Summer School of the Massachusetts Agricultural College will open June 26, 1916, for a term of four weeks. The work of the summer school was designed originally for teachers, and the attendance has been largely of that class. Special attention will be given to the needs of teachers again this year. It has been found, however, that there are many persons who seek a general knowledge of theoretical and practical agriculture, and who can come to the

college conveniently during the summer season. Practical courses are offered for the benefit of such persons.

The formal instruction in the summer school is given in definite courses. Each student may elect not less than 10 nor more than 15 exercises a week, unless a larger or smaller amount of work is allowed by the supervisor. These courses include a large amount of field work, observation trips, outdoor exercises and laboratory experiments.

General field exercises are arranged for one afternoon of each week. These are on topics of interest to all. Excursions are arranged for every Wednesday afternoon, and more extended excursions for the whole school are planned for every Saturday. These excursions are in charge of an instructor. In the past they have proved a very enjoyable feature of the work. Round-table and special discussions are arranged by the various instructors as their courses require.

A course of evening lectures on popular topics relating to the work of the school is a feature of the general program. This lecture course is free to all students.

Early registration is desirable. Registration fee for the summer school is $5, payable at the time application is made. No other tuition is charged. This fee should accompany application blank and should be made payable to the Massachusetts Agricultural College.

2. The School for Rural Social Service. — The Massachusetts Agricultural College offers a School for Rural Social Service in connection with the usual Summer School of Agriculture and Country Life. The courses offered give instruction, furnish information and direct the attention of those interested more particularly to the rural field, which has as yet received little systematic study when compared with that which has been given to urban conditions.

The courses offered are intended for clergymen, teachers, librarians, town officers, grange workers and others who devote a considerable portion of their time to problems of community development. Other courses given in the summer school during this period are also open to those who register. There is a registration fee of $1 for those attending this school. The dates for 1916 are July 11 to 25.

3. School for Library Workers. — During the summer of 1915 a very successful School for Library Workers, of one week's duration, was held at the college. The work was planned especially for those librarians and library assistants in village and rural libraries whose special training and experience had necessarily been limited. This school will again be offered in 1916 from July 17 to 22.

4. Poultry Convention. — In order to give a large number of poultrymen, who cannot come to the college for a long period of time, practical instruction in modern methods of breeding, feeding, poultry-house construction, operation of incubators and brooders, selecting and judging poultry for utility and for show, and in marketing poultry products, an annual three-day convention is offered. This will be held from July 19 to 21, 1916, inclusive.

5. Agricultural Camps. — During the month of July three camps are arranged in order that boys from rural districts and small towns may receive some instruction in agriculture and clean, wholesome sports, and that they may have impressed upon them their responsibilities as coming members of society. The daily program consists of camp duty, flag raising, agricultural lessons, talks on hygiene and good citizenship, play and recreation, instruction in

handicrafts, photography, evening camp fires and lectures by men prominent in boys' work. A small fee is charged to help defray the cost of board and incidental expenses. As a third prize in the State-wide boys' and girls' clubs a week in camp at the college is offered. The third boys' camp is given over to these prize winners, usually 35 to 40 in number. A separate camp, upon a slightly different plan and under different supervision, is held for the girl prize winners of the previous year.

6. CONFERENCE ON RURAL ORGANIZATION. — This conference is held as a closing feature of the summer school each year. It takes up various problems of New England country life. Numerous State organizations co-operate with the college in providing the programs. Section meetings of various groups are held each forenoon, a general round-table discussion is held each afternoon, and lectures are delivered each evening by persons prominent in social and educational work. Many small group conferences are also arranged.

The holding of this conference in 1916 is now under advisement, and it may be omitted owing to the fact that the Graduate School of Agriculture is to be held at the Massachusetts Agricultural College in 1916. If held, the dates of the conference will probably be July 25 to 28, inclusive.

The faculty of the 1915 summer schools was as follows: —

KENYON L. BUTTERFIELD, LL.D., President of the College and Head of the Division of Rural Social Science.
WILLIAM D. HURD, M.Agr., Director of the Extension Service and Supervisor of Short Courses.
WARREN S. BAKER, B.Sc., Instructor in Agronomy.
JOHN L. BYARD, Superintendent of Apiary.
ADA M. CHANDLER, B.A., Library Cataloguer.
WALTER W. CHENOWETH, Associate Professor of Pomology.
WILLIAM D. CLARK, A.B., M.F., Professor of Forestry.
LAURA COMSTOCK, Extension Professor of Home Economics.
SAMUEL COONS, Instructor in Dairying.
PHILIP H. ELWOOD,[1] Jr., B.Sc.Agr., Extension Instructor in Civic Improvement.
REV. WM. F. ENGLISH, Ph.D., Pastor, East Windsor, Conn.
R. HAY FERGUSON,[2] B.Sc.Agr., Extension Professor of Agricultural Economics.
HENRY T. FERNALD, Ph.D., Professor of Entomology and Chairman of the Division of Science.
JAMES A. FOORD, M.Sc.Agr., Professor of Farm Administration and Head of the Division of Agriculture.
BURTON N. GATES, Ph.D., Associate Professor of Beekeeping.
HAROLD M. GORE, B.Sc., Assistant in Physical Education.
JOHN C. GRAHAM, B.Sc., Professor of Poultry Husbandry.
CHARLES R. GREEN, B.Agr., Librarian of the College.
F. JOSEPHINE HALL, A.M., Adviser for Women.
IDA E. HALL, LL.B., Plays and Pageants.
HARRIET J. HOPKINS,[1] B.Sc., Extension Instructor in Home Economics.
WILLIAM P. B. LOCKWOOD, M.Sc., Professor of Dairying.
A. H. MACLENNAN, Lecturer in Horticulture, MacDonald College, Quebec.
CHARLES J. MAYNARD, Naturalist and Lecturer on Bird Life.
FREDERICK A. MCLAUGHLIN, B.Sc., Instructor in Botany.
EZRA L. MORGAN, A.M., Extension Professor of Community Planning.
ORION A. MORTON, Extension Professor of Agricultural Education.
ETHEL H. NASH, Extension Instructor in Agricultural Education.
ARNO H. NEHRLING, Associate Professor of Floriculture.
A. VINCENT OSMUN, M.Sc., Associate Professor of Botany.
SAMUEL R. PARSONS, B.Sc., Instructor, Pennsylvania State College.
CHARLES A. PETERS, Ph.D., Associate Professor of Inorganic and Soil Chemistry.
ELVIN L. QUAIFE, B.Sc.Agr., Assistant Professor of Animal Husbandry.
FREDERICK W. RIED, Director of Practical Arts, Framingham (Mass.) Normal School.

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[1] Resigned.

[2] Deceased.

Henry K. Rowe, Ph.D., Newton (Mass.) Theological Seminary.
Walter Ruetschi, Assistant Director of Athletics, New Jersey Public Schools.
Fred C. Sears, M.Sc., Professor of Pomology.
Frank A. Waugh, M.Sc., Professor of Landscape Gardening and Head of Division of Horticulture.

A bulletin describing the summer schools is issued in March each year, and may be had upon application to the Supervisor of Short Courses.

C. Graduate School of Agriculture.

A Graduate School of Agriculture to be held at the college from July 3 to 28, 1916. Every possible effort will be made to correlate the work of the various summer schools with the work of the graduate school, in order that students in each may benefit to the largest possible degree by the opportunities presented by the other.

D. Miscellaneous Short Courses.

1. Short Courses for Special Groups. — Plans are now under way to provide short courses at Amherst, lasting four or five days, for fertilizer agents, feed agents and dealers, milk inspectors, seed dealers and other groups desiring such instruction. Information concerning these may be obtained by writing the Supervisor of Short Courses.

2. Special Days for Foreigners. — Each year there are provided at the college special days for foreigners. Instruction is given in soil management, co-operation, American citizenship and history. This work for foreigners will be arranged at the college, or in different sections of the State.

3. Meetings of Organizations at the College. — It is customary for the various State organizations of fruit growers, poultrymen, breeders and others to meet for conventions and picnics at the college. Such gatherings are welcomed by the college authorities, and organizations are cordially invited to meet in Amherst. The Extension Service will assist in arranging programs and other forms of instruction and entertainment.

All requests for announcements or further information regarding any of the short courses should be addressed to the Supervisor of Short Courses, Massachusetts Agricultural College, Amherst, Mass.

THE EXTENSION SERVICE.

What is known as the Extension Service is an organized effort on the part of the college to carry systematic and dignified instruction to the thousands of people throughout the State who are unable, owing to various reasons, to take advantage of the regular courses offered at the college. It is in reality the "carrying of the college to the people of the State." Every department of the institution, in so far as the regular teaching and research work will permit, contributes what it can to this work. The work may be roughly classified under the following general heads: general administration; correspondence study; itinerant instruction which includes lectures and lecture courses, exhibits, demonstrations and extension schools; extension work through the various departments of the college, in which the extension specialist is responsible to the head of the department for the technique of the work and to the director of the extension service for the accomplishment of the work; co-operative work of various kinds with the United States Department of Agriculture; and extension work through county, district and local agents. Some of the ways in which this is being done are described briefly below.

CORRESPONDENCE COURSES. — The purpose of the correspondence courses is to furnish systematic instruction in those lines which will most benefit the general farmer, the dairyman, the fruit grower, the market gardener, the poultryman, the teacher, the homemaker, and all others who are interested in agricultural and country-life matters. It is the purpose to present up-to-date, accurate and concise information in such a manner and in such language that all who pursue the study may readily understand the work.

Courses offered. — A number of courses are in process of revision and several are being rewritten. During 1916 courses will be available as follows: —

1. Soils and Soil Fertility. Professor HASKELL.
2. Manures, Fertilizers and Soil Amendments. Professor HASKELL.
3. Field Crops. Assistant Professor JONES.
4. Farm Dairying. Professor LOCKWOOD.
5. Fruit Growing. Professor SEARS, Associate Professor CHENOWETH and Mr. REES.
6. Market Gardening. Assistant Professor A. S. THOMSON.
7. Animal Feeding. Mr. TURNER.
9. Farm Accounts. Professor FOORD.
10. Entomology. Dr. REGAN.
12. Beekeeping. Associate Professor GATES.
13. Forestry. Professor CLARK.
14. Shade Tree Management. Associate Professor OSMUN.
17. Poultry Husbandry. Professor GRAHAM.
18. Home Economics. Extension Professor COMSTOCK.
19. Rural Sociology. Professor PHELAN and Mr. BAIRD.

Methods of conducting the Work. — The best known methods of conducting correspondence course teaching are employed. Certain courses are based entirely upon text-books, others consist wholly of typewritten lectures, while still others combine the two. Even when books are not required they are usually recommended for reference or collateral reading.

The courses are designed primarily for the individual student. A new phase of the work, however, is the organization of study clubs or classes, meeting together periodically and using the courses as a basis of study. Correspondence in regard to this work is invited.

Enrollment of Correspondence Courses. — Students may enroll in the courses at any time between October 1 and June 1, and one year from the date of registration is allowed for the completion of each course. It has been found advisable to discontinue the courses through the summer months, as farmers and most other students cannot devote the necessary amount of time to the lessons during this season.

Expenses of the Correspondence Courses. — In order that none shall enroll except those who are interested and desire to pursue earnest study, a small fee is charged. This has been fixed at $1 for each course except where the courses are divided, and it has been found advisable to charge $1 for each of the parts in these instances. The fee is payable strictly in advance, at the time the enrollment card is sent. When text-books are required the student purchases these.

LECTURES AND DEMONSTRATIONS. — The members of the faculty of the college are, when other duties will permit, available for lectures and demonstrations before granges, men's clubs, women's clubs, Y. M. C. A.'s, farmers' clubs, boards of trade and other organizations. A list of more than 40 lecturers and 200 subjects on various phases of agriculture, country life, economics, sociology, education, civic betterment and various scientific subjects has been prepared. Full courses of lectures or single lectures may be arranged.

Organizations arranging the lectures are asked to pay the traveling expenses of the lecturer, provided no admission fee is charged. When admission is charged the lecturer is entitled to a fee in addition to traveling expenses.

EXTENSION SCHOOLS. — The extension schools are of two distinct types, the first being the Agricultural Extension School, dealing with the production side of farming and with the problems of the farm home; the second is the Extension School in Community Planning, having to do with the organization and selling end of agriculture, and with instruction in the planning and carrying forward of various community activities.

It is also possible to arrange special extension schools along one particular line of work, such as fruit growing, dairying, etc.

Communities desiring an extension school make a written request, agreeing to defray all local expenses, such as the rent, heating and lighting of a suitable hall, and the board of the instructors during the school.

Agricultural Extension Schools. — The college sends a corps of instructors to a town for a five-day school of instruction. At present the following courses are offered: soil fertility, animal husbandry and dairying, fruit growing, poultry husbandry and vegetable gardening for the men, and a homemakers' course for the women. Morning and afternoon sessions only are held.

Community Planning Extension Schools. — These schools are arranged to extend over at least three days. The following courses are offered: education, agricultural organization, community program, civic improvement, farm management, town administration, public health, community recreation and homemaking. Morning, afternoon and evening sessions are held in these schools.

EDUCATIONAL EXHIBITS AT FAIRS AND OTHER SHOWS. — The college coöperates with the managers of fairs, industrial expositions, corn shows, poultry shows, fruit shows and other exhibitions by making educational exhibits.

For outside work a large tent has been provided. In this about thirty cabinets containing educational material are arranged. A corps of lecturers and demonstrators accompany the exhibit and give practical instruction daily.

For inside work a space at least 40 by 60 feet is required for this exhibit. Smaller exhibits along special lines are sent to corn, fruit and poultry shows, milk shows, child welfare exhibits, and so forth.

The managers of fairs and exhibits are required to partially meet the cost of presenting these exhibits.

EXTENSION WORK IN SPECIAL FIELDS.

EXTENSION WORK IN FRUIT GROWING. — This work includes lectures and demonstrations on laying out and planting orchards, pruning, spraying, thinning, grading, packing and marketing fruits. Demonstration orchards, new and renovation plots, are established in different sections of the State, under a coöperative agreement between the college and the owners of land. Extension schools in fruit growing and fruit grading and packing are arranged on request. Visits to farms for advisory work are made, and correspondence on orcharding subjects are invited.

Extension Work in Animal Husbandry. — This work includes lectures, demonstrations and advisory assistance on subjects pertaining to cattle, horses, sheep and swine, as well as instruction in barn planning. Assistance in organizing dairy improvement associations and breeders' associations is given; stock-judging contests for boys are arranged at the leading fairs.

Extension Work in Dairying. — This includes lectures and demonstrations on the handling and care of milk, cream, butter and cheese; Babcock testing, dairy utensils and dairying manufactures. Educational campaigns may be arranged in different communities, seeking to educate producers, dealers and consumers as to the production and distribution of clean, safe milk.

Extension Work in Poultry Husbandry. — In addition to conferences at the college and visits to the plants of poultrymen, advice on general poultry management, diseases, mating and laying out and planning buildings, this work includes co-operative work with other State and county agricultural and educational organizations, exhibits of poultry appliances at fairs and shows and other incidental phases.

Extension Work in Farm Management, Field Studies and Demonstrations. — This is carried on coöperatively between the college and the office of farm management of the United States Department of Agriculture at Washington. It consists of a study of farm conditions and farm management problems; instruction in keeping farm accounts and growing field crops; the use of fertilizer and lime; advice as to farm equipment, buildings, and so forth.

Extension Work in Civic Improvement. — This is carried on in connection with the Department of Landscape Gardening at the college. Assistance is rendered in various rural and village improvement enterprises, such as the planting and care of shade and street trees, the planning of playgrounds, school grounds, cemeteries, picnic grounds, the beautifying of waterfronts, the rearrangement and development of town commons and reservations of historic interest, and similar activities. Efforts are made to coöperate with local granges, men's and women's clubs, village improvement societies and like organizations.

Extension Work in Agricultural Education. — This is an organized effort to promote in the public schools of the State the study of agriculture and practical arts relating to country life. This is accomplished by means of conferences with school officials and school patrons, the promotion of agricultural clubs among the school children, and lectures before granges, farmers' clubs and other interested organizations. The work of the agricultural clubs is under the direction of the superintendent of schools or some one recommended by him. Each town should hold an annual exhibit of products. Exhibits representing rather extensive districts are incorporated with the various agricultural fairs in the State. In this manner elementary instruction in agriculture is promoted by the combined efforts of the public schools, of the patrons of the schools through their agricultural fairs, and of the Agricultural College, which in turn coöperates with the State Board and the National Department of Agriculture.

Extension Work in Home Economics. — The Extension Service, through its home economics workers, stands ready to assist in solving problems relative to the household in the same manner as it is endeavoring through other workers to aid in working out problems of the farm. The work, among other things, includes lectures and demonstrations, assistance in forming girls' clubs and home economics clubs for women, and coöperation with existing organizations in the matter of interesting young people in the proper care of the home.

Extension Work in Community Planning. — A number of communities in the State have appealed to the college for aid in bringing the various organizations in the community to a higher state of efficiency, in order that they themselves might take definite steps toward community development and advancement. The college is now prepared to make scientific studies of communities which lead up, by means of surveys, to the organization of local committees to study the agricultural, educational, religious, transportation, recreation and civic needs of the communities. Several State organizations and some national organizations are usually brought in to aid in working out the plans presented by these committees. Conferences on community affairs are held upon request. The college acts merely in an advisory capacity, the communities themselves doing the actual organization work.

Library Extension Work. — This consists principally of loaning to public libraries of the State general collections of 10 to 30 books and bulletins on agriculture and related subjects. Special collections of smaller size on specified subjects, such as fruit growing, dairying, poultry, beekeeping, home economics, and so forth, are also sent out. These may be kept from four to eight weeks, according to the demand for them. The only expense to local libraries is transportation charge on the books both ways. The college library also supplies, upon request, information regarding books on agriculture and related subjects.

Agricultural Surveys. — To acquire definite information as to existing conditions in rural communities, to be used as a basis for further extension work, agricultural surveys are made. The different organizations and officials in the community, such as the town officers, superintendent of schools and teachers, clergymen, librarians and others, usually co-operate in making such surveys. The survey covers all phases of community life, including soil survey, farm management practices, and the educational, social, religious and recreational life. The inventory is made upon carefully prepared blanks.

Business Co-operation and Marketing. — This work has for its object the establishment of agriculture on a better business basis. Assistance is given in organization of co-operative buying and selling associations, the securing of rural credit, the adoption of better methods of marketing, the establishment of a better market for agricultural produce, and other lines of agricultural co-operation.

Massachusetts Agricultural College Agricultural Improvement Association. — This is an organization of ex-students of the college who are now farming in the State, and who have banded themselves together for the purpose of promoting the agricultural development of the State by carrying on experiments and demonstrations for the betterment of rural pursuits, by using and encouraging the use of better seeds and animals, by the organization of co-operative societies, and by the dissemination of literature bearing on recent agricultural investigations. Production of high-grade strains of corn and potatoes for the Massachusetts seed trade and work for the improvement of animals are some of their activities.

Demonstration Farms and Plots. — Believing that one of the most effective ways of teaching modern farm practice is by the establishment of demonstrations (not experiments) in all sections of the State, thus showing a man on his own land and under his own conditions the result of proper farm practices, the college is placing demonstration plots throughout the State, showing the proper fertilization for grass and other crops, the results of rotations, the proper care of orchards and dairy management. For several years the Faunce Demonstration Farm has been under the advisory direction of the college, as is also the Paige farm at Hardwick. The Faunce farm has proved to the Cape Cod region that small fruit, poultry and vegetables can be successfully grown there. Demonstration farms are usually managed by a committee or board of trustees representing the farm and a committee appointed from the college acting jointly.

County or District Agricultural Agents. — As rapidly as State, government and local funds are available, men trained in agriculture are being assigned to counties and districts of the State to act as agricultural agents. Residents of the county or district may, without cost, call upon the agent for assistance upon any agricultural subject. The work is being supported through the co-operation of the United States Department of Agriculture, the college and the community engaging the agent.

Advisory Work with Institutions and Individuals. — Special effort is made to comply with as many of the requests of State institutions and individuals who ask for advice on farm problems as possible. The force of instructors available for this work is at present insufficient to take care of all the demands. Special trips, including visits to a number of the various State institutions, are occasionally made by a group of specialists.

Publications of the Extension Service. — In addition to the regular circulars and bulletins which announce the various short courses and lines of work mentioned, a monthly pamphlet, "Facts for Farmers," giving timely information on agricultural subjects, is issued. Large numbers of helpful circulars and bulletins are annually distributed. A series of bulletins especially for the farm woman is one feature of this work. Reports of the work of the Extension Service, dairy record blanks, farm account blanks, boys' and girls' club circulars, lists of books, and so forth, may be had upon request.

Co-operation with Other Organizations. — The aim of the Extension Service is to co-operate with existing organizations so far as possible. It is, therefore, glad to work with local organizations, and welcomes suggestions from town officers, local granges, farmers' clubs, women's clubs, Y. M. C. A.'s, Y. W. C. A.'s, boards of trade, village improvement societies, teachers, clergymen, librarians and others interested in agriculture and country life, as to needs and methods best adapted to the meeting of these needs.

Information by Correspondence. — Besides the activities mentioned, hundreds are helped through personal visits to farms, and still larger numbers through letters of inquiry, which always receive the most careful attention from every department of the institution.

Pamphlets and bulletins are sent free to all who apply for them, and any who desire such help as has been mentioned should address the Director of the Extension Service, Massachusetts Agricultural College, Amherst, Mass.

GENERAL INFORMATION.

GENERAL INFORMATION.

A. FINANCIAL AND ADMINISTRATIVE.

STUDENT EXPENSES.

TUITION.[1] — Tuition is free to residents of Massachusetts. Students who are not residents of Massachusetts are charged a tuition fee of $40 a year. The tuition charged persons not citizens of the United States is $120 a year. Students entering from Massachusetts are required to file with the president a statement signed by either town or city clerk stating that the applicant's father is a legal resident of Massachusetts; a similar statement is required of those entering from other States.

All students entering the college for the first time as undergraduates or unclassified students are charged a matriculation fee of $5, which in event of a student leaving the institution shall, if all bills due the college are paid, be remitted, or which shall upon graduation be considered as payment for the diploma.

DORMITORIES AND BOARD. — The college has dormitory accommodations for about 62 students. The rooms in the dormitories are occupied by the upper classmen, hence new students find it necessary to room in private houses. The rooms in the college dormitories are unfurnished; for the most part they are arranged in suites of three, — one study room and two bedrooms. These rooms are heated by steam and lighted by electricity; they are cared for by students occupying them. The dormitory rent for each person varies from $39 to $66 a year. The rent for furnished rooms in private houses ranges from $1 to $3 a week for each occupant. Correspondence in regard to rooms should be addressed to the dean of the college.

Board may be obtained at the college dining hall. At present the price of board there is about $4 a week. Board is furnished at cost, the price being determined by adding 5 per cent. to the audited rate for the previous three months, and at the end of the period final settlement is made on the basis of actual cost.

EXPENSES.

The necessary college expenses are estimated as follows: —

Tuition: citizens of Massachusetts free; other citizens of the United States, $40 a year; foreigners, $120 a year.

	Low.	High.
Matriculation fee, first year,	$5 00	$5 00
Room in college dormitories or in private houses,	39 00	110 00
Board in college dining hall, $4 a week,	144 00	144 00
Laundry, 50 cents to 85 cents a week,	18 00	30 00
Military uniform, first year,	16 40	16 40
Laboratory fees,	2 00	20 00
Books, stationery and miscellaneous items,	15 60	24 60
	$240 00	$350 00

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[1] This statement applies to those registering as regular or unclassified students.

OTHER EXPENSES. — Prospective students should understand that the above estimates cover expenses which may be called strictly college expenses, and that there are other financial obligations voluntarily placed upon students which they should expect to meet. Chief among these are class assessments and taxes levied for maintenance of various organizations, such as the Social Union, Athletic Association, weekly publications, etc. Such expenses vary from $15 to $30 a year. Additional financial responsibility is also assumed by students joining a fraternity or entering into other social activities of the college. Students rooming in college dormitories are obliged to equip their own rooms with furniture. The college assumes no responsibility in regard to the safe keeping of student property either during the college term or vacations, except under such special arrangement as may be made with the treasurer. Besides the amount necessary for clothes and traveling, the economical student will probably spend between $275 and $375 per year.

INITIAL CHARGES.

At the opening of the college year, before students are registered in their classes, the following charges are payable at the treasurer's office: —

	Freshmen.	Sophomores.	Juniors and Seniors.
Matriculation fee, ...	$5 00	-	-
Board (if at college dining hall) four weeks in advance,	16 00	$16 00	$16 00
Assessment for support of Social Union, . . .	1 00	1 00	1 00
Laboratory fees: —			
Chemistry, ...	5 00	-	-
Zoölogy, ...	-	2 00	-
For elective subjects, ...	-	-	1 00-10 00
Military uniform,[1]	16 40	-	-
Room rent (if in college dormitory), ...	-	-	19 50-33 00
Student tax for support of athletics,[2] . . .	8 00	8 00	8 00
Student tax for support of nonathletic activities,[2]	2 50	2 50	2 50

[1] This cost is subject to modification from year to year.

[2] While this is not essentially a college charge, the treasurer of the college acts as collector for the student activity, and all students are expected to make the payment as indicated. The subscription price of the "Collegian" is fixed by the managers; the amount of athletic tax by vote of the student body.

LABORATORY FEES.

The principles observed in establishing laboratory fees are the requirement that students pay for those materials actually used which cannot be supplied by the individual, and that the laboratory fees include a charge sufficient to guard against wanton waste and breakage. Fees may be established for any course without previous announcement. At present, the fees charged are as follows: —

	Per Semester.
Agronomy: —	
Course 3,	$1 50
Course 4,	50
Courses 5 and 6,	1 00
Animal husbandry: —	
Courses 2 and 4,	1 00
Course 7,	2 00
Botany: —	
Courses 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,	3 00
Course 4,	2 00
Course 5,	1 00
Chemistry: —	
Courses 1, 2, 7, 8, 13, 15,	3 00
Courses 3, 4, 5, 6,	4 00
Courses 9, 10, 11, 12, 14, 16,	5 00
Dairying: —	
Courses 1, 2, 3,	1 00
Entomology: —	
Courses 3, 4,	3 00
Landscape gardening: —	
Landscape gardening 1, 2,	2 50
Landscape gardening 3, 4, 7, 8,	3 00
Landscape gardening 6,	1 00
Drawing 1, 2,	2 50
Mathematics: —	
Courses 6, 10,	1 00
Microbiology: —	
All courses, each,	5 00
Pomology: —	
Courses 3, 4,	2 50
Poultry Husbandry: —	
Course 3,	1 50
Course 4,	2 00
Zoölogy: —	
Course 1,	2 00
Courses 3, 4,	4 00

STUDENT AID.

Self Help. — Many students are obliged to find work of some sort to earn their way through college. A few men have met their entire expenses in this manner, many more have paid a large part of their expenses, and many have earned a small proportion of the cost of their college education; but the college recommends that no new student enter without having at least $150 with which to pay his way until he can establish himself in some regular work. The college does not encourage students to enter without money in the expectation of earning their way entirely. The ordinary student will find it better either to work and accumulate money before coming to college, or to take more than four years in completing his college course, or, instead, to borrow money sufficient to carry him through. No student should undertake work that interferes with his studies, and students should understand that, owing to the large number of applications for employment, no one man can receive a large amount of work at the college. A number of students find opportunities for earning money without depending upon the college to furnish them with work.

So far as possible needy students will be employed in some department of the college. The divisions of agriculture and horticulture usually afford the most work, although there are several permanent janitorships available for students, and sixty or more students are employed at the dining hall. Application for student labor should be made directly to the President. Applicants are required to present statements from parent or guardian and from a selectman or alderman of the town or city in which they reside, showing that the applicant needs assistance. Students whose deportment or class work is not satisfactory are not likely to be continued in student labor. The most desirable and responsible positions are naturally assigned to those needy students who have been in the institution longest and who have demonstrated their need and ability. Students, therefore, may find it rather difficult to obtain all the work they desire during their freshman year; as a matter of fact, however, any student who is capable of doing a variety of things, and who is a competent workman, usually finds little difficulty in obtaining all the work that he can do from the outset.

Special Notice to Needy Students. — In the last few years the demand for paid labor on the part of new students has far exceeded the amount of employment that the college can offer. The college cannot promise work to any student, particularly to freshmen; it accordingly urges prospective students who are dependent entirely upon their own efforts not to undertake the course before they have earned enough money to carry them through, or nearly through, the first year.

STUDENT ACCOUNTS.

The following rules are enforced concerning student accounts: —

No student will be allowed to graduate until all bills due the institution from him are paid.

College charges, such as room rent, laboratory fees and tuition, must be paid in advance, at the beginning of each semester. This rule is strictly adhered to, and no student will be allowed to register in his class until such payments are made.

Every student boarding at Draper Hall is required to pay at the beginning of each semester at least one month's board in advance; and no student will be allowed to continue to board at Draper Hall if at any time during the semester he is more than one week in arrears in his payment for board.

All money due for student labor shall at the discretion of the treasurer of the college be applied on account toward any bills that a student may owe to the institution.

STUDENT RELATIONS.

The customary high standard of college men in honor, manliness, self-respect and consideration for the rights of others constitutes the standards of student deportment.

Any student known to be guilty of dishonest conduct or practice must be reported by the instructor to the president for discipline.

The privileges of the college may be withdrawn from any student at any time, if such action is deemed advisable.

It should be understood that the college, acting through its president or any administrative officer designated by him, distinctly reserves the right not only to suspend or dismiss students, but also to name conditions under which students may remain in the institution. For example, if a student is not doing creditable work he may not only be disciplined but he may also be required to meet certain prescribed conditions in respect to his studies, even though under the foregoing rules his status as a student be not affected. The same provision applies equally to the matter of absences ("cuts"). According to the rules a student is allowed a certain percentage of absences from class and other exercises. This permission, which implies a privilege and not a right, may be withdrawn at any time for any cause.

Similarly, also, it applies to participation in student activities. Though this will ordinarily be governed by the rules as already laid down, yet, if in the judgment of the college authorities a student is neglecting his work on account of these activities the privilege of participating in them may be withdrawn for such time as is considered necessary. Moreover, it may be withdrawn as a punishment for misconduct. Prospective students or their parents may, upon application, obtain a copy of the faculty rules governing student relations to the college.

INFIRMARY.

The college maintains an infirmary for the care of sick or injured students. The buildings now available for this purpose are quite inadequate for the needs of the institution, and it is hoped that in the near future other buildings of this kind may be erected and the general equipment somewhat amplified. At present two small buildings, built especially for hospital purposes, are used for the infirmary.

The following statement outlines the plan followed in the management of the infirmary with respect to students: —

Management of the Infirmary.

Supervision.

1. The infirmary is under the *general supervision* of Dr. Charles E. Marshall, who is designated as Supervisor of the Infirmary. Miss Florence Levensaler, the resident nurse, is in *immediate* charge of the infirmary.

Use of Infirmary.

2. Students are urged to go to the infirmary at any time that they are in need of the services rendered by the resident nurse or by a town physician. Inasmuch as Professor Hicks gives special attention to all student diseases, it is to be expected that the majority of the students will go to the infirmary at the suggestion of Professor Hicks. This understanding, however, should in no way deter students from going to the infirmary voluntarily at any time.

General Health.

3. Students are urged to consult Professor Hicks or Miss Levensaler immediately when signs of physical disorder appear. Severe attacks of cold or other forms of illness can usually be avoided if treatment is administered in the in-

cipient stage. The purpose of the infirmary is to help maintain the general good health of the students, as well as to furnish a suitable place for professional attention in cases of severe illness or accident.

General Fee.

4. The infirmary fee will be at the rate of $1 a day, and will be charged when one or more meals are obtained at the infirmary, or when the student remains at the infirmary for one or more nights. No charge will be made for miscellaneous treatment of a minor character unless the patient receives one or more meals or remains at the infirmary for one or more nights.

Additional Expenses.

5. In addition to the fee charged, as specified in paragraph 4, the following additional expenses will be charged to the patient: —

(*a*) *Nurses.* — In case a special nurse is required for the proper care of an individual, the services and board of this nurse will be paid by the patient. Such a nurse will be under the general supervision of the resident nurse.

(*b*) *Professional Service.* — If a student requires medical attention by a physician, he will be required to select his physician and become responsible for fees charged by the physician.

(*c*) *Supplies.* — Special medical supplies prescribed by a physician or nurse will be charged to the patient. No charge will be made for ordinary medical supplies kept in stock at the infirmary and furnished students in minor cases of illness or accident.

(*d*) *Laundry.* — Expense for personal laundry incurred by students while in the infirmary will be charged to the individual student.

B. COLLEGE ACTIVITIES.

GENERAL EXERCISES.

Chapel exercises are held two mornings each week. On Wednesday an afternoon assembly is held, to which some prominent layman or professional man is invited to speak. The object of these assemblies is to bring to the students discussions of topics of present-day interest. A special chapel service on Sunday is usually held during the winter months. Students are required to attend these general exercises, although the president is authorized to excuse from chapel any student who may object to attendance thereon because of his religious scruples, provided his request for excuse therefrom is endorsed by his parent or guardian.

STUDENT ACTIVITIES.

A large number of student organizations furnish opportunity to students for work and leadership.

The Massachusetts Agricultural College Social Union was established about six years ago. All students become members of the union by paying a small fee. The union is designed to become the center of student interests. In North College it has a trophy room and a large lounging room for music, reading and study; in the basement of this building there is also a game room for pool and billiards. In the fall and winter months the union gives a series of entertainments, free to students and faculty.

The College Senate is composed of representatives of the junior and senior classes. This body serves as a general director of undergraduate conduct, and represents before the faculty the interests of the student body.

The Young Men's Christian Association is active both socially and religiously. Under its direction voluntary Bible classes are conducted during the winter months. A Catholic club has also been organized.

The musical organizations include an orchestra, a mandolin club and a glee club. These furnish music for college meetings, and occasionally give concerts at the college and at other places. A military band is maintained as part of the cadet corps.

A dramatic club has been organized, and each year presents a play.

The Public Speaking Council represents the students' interest in debate and oratory.

The Athletic Association represents in the college the interests of football, baseball, track, hockey and tennis.

A rifle club has been organized for a few years. Teams representing this club have repeatedly won the intercollegiate championship of the country, both in indoor and outdoor contests.

The college publications are the "Massachusetts Collegian," published weekly by the student body, and the "Index," published annually by the members of the junior class.

The Stockbridge Club is an organization of students especially interested in practical agriculture and horticulture. Regular meetings are addressed by outside speakers, and members present papers and engage in discussions.

Scientific clubs also exist in the Departments of French, Entomology, Landscape Gardening and Zoölogy.

There has recently been organized a Collegiate Country Life Club, the membership of which is composed of faculty and students who are particularly interested in the study of country life problems.

A nonathletics student activities board, composed of alumni, faculty and students, has charge of the finances, schedules, etc., of the musical clubs, dramatic club and student publications.

C. ACADEMIC AND DEPARTMENTAL.

DEGREES.

Those who complete a four-year course receive the degree of bachelor of science. The fee for graduation from the college is $5.

Graduate students who complete the assigned courses will receive the degree of master of science upon the payment of a fee of $10. Credit may sometimes be allowed towards this degree for teaching or other advanced work done in some department of the college.

Graduate students who complete the required three-year course of study, and present a satisfactory thesis, will be granted the degree of doctor of philosophy.

Those to whom degrees are awarded must present themselves in person at commencement to receive them. No honorary degrees are conferred.

The honorary fraternity of Phi Kappa Phi has a chapter at the agricultural college. Students are elected to membership to this fraternity on the basis of scholarship. Elections are made from the highest fifth of the senior class who have attained an average grade of at least 85 per cent. during their college course.

PRIZES.

Prizes are given annually in several departments for excellence in study or for other special achievement. Prizes offered in 1914 were: —

Agriculture. — The Grinnell prizes (first, second and third), given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture. They are $25, $15 and $10.

Animal Husbandry. — The F. Lothrup Ames prize, given by F. Lothrup Ames, Langwater Farms, North Easton, Mass., consisting of $150 a year, offered for a period of five years, beginning 1912, to be given to the three students standing highest in the work of advanced live stock judging, and to be used in defraying their expenses incurred by participation in the students' judging contest at the National Dairy Show, Chicago.

Botany. — The Hills prizes, given by Henry F. Hills of Amherst, amount to $35 annually. Competition is open to members of the senior, junior and sophomore classes as follows: for the best herbarium, $20; for the second best herbarium, $15. No collection deemed unworthy of a prize will be considered.

Entomology. — In 1914 a special prize of $5 was offered to that member of the junior class presenting the best collection of insects.

General Improvement. — The Western Alumni Association prize ($25) is given to that member of the sophomore class who, during his first two years in college, has shown the greatest improvement in scholarship, character and example.

Public Speaking. — The Burnham prizes are awarded as follows: to the students delivering the best and second best declamations in the Burnham contest, $15 and $10, respectively. The preliminary contests in declamation are open, under certain restrictions, to freshmen and sophomores.

The Flint prizes are awarded as follows: to the students delivering the best and second best orations in the Flint contest, a gold medal and $20 and $15, respectively. The preliminary contests in oratory are open, under certain restrictions, to all regular students.

The prizes in debate are awarded as follows: to each of the three students ranking highest in the annual debating contest, a gold medal and $15. The preliminary contests in debate are open, under certain restrictions, to all regular students.

EQUIPMENT.

Agricultural Education. — The courses in this department are planned primarily for those who are preparing to teach. The work is carried on by means of lectures, library and demonstrations. The department has an office, lecture room and a laboratory in the Veterinary Science building. The laboratory is equipped with a balance, dishes, jars, reagent bottles, test tubes, petri dishes, lenses, a Babcock test, a Wisconsin sediment test, Bunsen burner, hot and cold water, electricity, gas and other appliances for giving demonstration and practice lessons in Secondary Agriculture. There is also equipment for conducting children's gardens on the campus. Instruction in school gardens constitutes a part of the practice work of those training for the occupation of teaching. Some practice work in teaching is done in the grammar grades of the Amherst schools, and in the agricultural departments of Hopkins' Academy, and Smith's Agricultural School at Northampton. This department is also intimately related to the matter of recommending candidates for teachers' certificates. At least four courses in the department are required of students preparing for such certificate. The office is supplied with school and college reports, also a large number of pamphlets and bulletins relating to the subject of agriculture in the schools, courses of study, etc. See note relative to teachers' certificates, under major in Agricultural Education.

Agronomy. — The work in agronomy is carried on by means of lecture, laboratory and field work. The soil laboratories are located in the basement of Stockbridge Hall, and include an elementary laboratory with locker equipment for 200 men, and desk space for four divisions of 50 men each, and an advanced soil laboratory for the work of upper classes, with locker space for 80 men. This laboratory is also equipped with balance room, centrifuge room, steam ovens and moisture cabinets. There is also a workroom attached, equipped with power for grinding soils, fodders and the like.

The crop laboratories are located on the second floor of Stockbridge Hall, the room for seed study being at the south end and allowing for sections of 50 men each. The laboratory for cereal and forage crop work is at the north end of the building, and has locker equipment for 64 men. This laboratory is equipped with large steam ovens, constant temperature electric ovens, Brown-Duval moisture apparatus and ovens for seed germination. Attached is a balance room and also a storeroom; while on the fourth floor of Stockbridge Hall is a room equipped for the storage of seed corn, grains and grasses.

Animal Husbandry. — An accurate and definite knowledge of the market types and grades, and of the various breeds of live stock, is fundamental to the work in this department. The department is equipped with an excellent laboratory, Grinnell Arena, which has a seating capacity of 180, and which is fully adapted to the requirements. There are upwards of 125 head of dairy cattle of various ages available for class-room work; among these are included superior representatives of the Jersey, Guernsey, Ayrshire and Holstein breeds. There are flocks of pure-bred Shropshire and Southdown sheep of the best breeding and individuality. Considerable numbers of pure-bred Berkshire and Yorkshire pigs are maintained. The college possesses pure-bred Percherons and French coach horses, besides many work teams of different types, which are available for class-room purposes. A set of plaster of Paris models of individuals of foreign and domestic breeds of horses, cattle, sheep and swine, and a collection of the different foodstuffs available for the use of the New England farmer, are included in the equipment for this work. An excellent set of upward of 250 lantern slides, portraying the leading prize-winning, producing and breeding animals of the leading breeds, — horses, cattle, sheep and swine, — belongs to this department, and is regularly used in instructional work. This equipment is being added to from time to time as funds are available.

Botany. — The Department of Botany occupies Clark Hall, a brick building 55 by 95 feet, two stories high, with basement and attic. It has two lecture rooms, one seating 154 and the other seating 72 people; one seminar and herbarium room; a large laboratory for sophomore and junior work, and one for senior work; and three rooms specially fitted for graduate students. The experiment-station laboratories devoted to botanical research are also in this building. A small museum contains material especially useful in the teaching and illustration of plant phenomena; and on the third floor is a collection of Massachusetts timber trees, specimens showing peculiar formations of plant growth, and various specimens illustrative of scientific methods of treating trees.

The laboratories and lecture rooms are of modern construction, finely lighted and supplied with all necessary conveniences. The basement contains a bacteriological laboratory, a seed and soil room; and a convenient workshop provided with benches for wood and metal work, an electric motor, a power lathe, and other tools and appliances. In the senior laboratory is a room designed especially for physiological work; this laboratory is well supplied also with apparatus for the study of simple phenomena in plant physiology, such as respiration, metabolism, transpiration, heliotropism, etc. The herbarium contains 18,000 sheets of flowering plants and ferns, 1,200 sheets of mosses, 1,200 sheets of lichens and liverworts, and about 20,000 specimens of fungi. The laboratory is equipped with 94 modern compound microscopes and a number of dissecting microscopes, microtomes and a large series of charts. A conservatory 28 by 70 feet is connected with the laboratory. This is designed for experiment work and for housing material often needed in the laboratory.

Chemistry. — The college Department of Chemistry occupies the entire building previously known as the "old chapel." The basement is used for the storage of apparatus and chemicals. The first floor contains large laboratories devoted to organic, physiological and physical chemistry, and qualitative analysis. The second floor is occupied by the general lecture room, by offices for the several members of the staff and by laboratories for analytical chemistry. The third floor has been fitted for work in general chemistry, and has desk room and hoods sufficient to accommodate 66 students at one time. Each place is supplied with reagents and apparatus for independent work. This floor is also occupied by a lecture room that will seat 100 students.

The entire laboratory is well equipped with the necessary apparatus and chemicals for all students who desire to perfect themselves as expert chemists, or who wish to study chemistry as a supplement to some other line of practical or scientific work. The equipment includes a valuable and growing collection of specimens and samples of minerals, soils, raw and manufactured fertilizers, foods, milk products, fibers, various other vegetable and animal products and artificial preparations of mineral and organic compounds; and also a series of preparations for illustrating the various stages of different manufactures from raw material to finished product.

Dairying. — The dairy work is given in Flint Laboratory, a new building designed for the dairy department. It contains large, well-lighted, sanitary and well-equipped laboratories. The equipment is new and of the best types of market milk and farm dairy machines.

Dining Hall. — Draper Hall, a brick colonial building equipped with the modern conveniences of a dining hall, was opened in 1903. The dining service is under the supervision of the college. The building contains a limited number of rooms for young women students.

Drawing. — The class in drawing occupies a room on the second floor of Wilder Hall. It is equipped with tables and adjustable drawing stands. The necessary materials and implements are provided. The equipment includes drawing models, and plaster casts of leaves, flowers, fruits, human and architectural details and garden ornaments, two universal drafting machines, an eidograph, centrolineads, a set of ship splines and French curves, complete water-color outfits, automatic crosshatchers and protractors.

Entomology. — *General Entomological Laboratories.* — The equipment for work in entomology is perhaps unexcelled in this country. In the new fireproof entomological and zoölogical building, first used in the fall of 1910, are fine lecture rooms, laboratories and museums for use in the different courses. The senior laboratory will accommodate 70 students at one time; a desk, equipped with compound microscope and accessories, together with glassware, reagents, etc., and supplied with electric light and gas, is provided for each student. Dissecting microscopes, microtomes and other apparatus are available for use. The graduate laboratory is similarly equipped, and it will accommodate 20 students. The large and rapidly growing collections of insects are in a room adjoining both laboratories. In the library of the building is an excellent collection of the more important books and journals treating of entomology, and many more are accessible in the college library and in the private libraries of the professors, in all making available more than 25,000 volumes, many of which cannot be found elsewhere in the United States. A card catalogue giving references to the published articles on different insects contains more than 60,000 cards, and is the largest index of its kind in the United States, and probably in the world. In the basement is a pump room where may be studied the construction of the different types of spray pump and methods of repairing them; hose, couplings, nozzles and the other parts of spraying outfits are provided, not only for examination but for use. In another room chemical desks and apparatus provide opportunities for the determination of the impurities and adulterations of insecticides. As the insectary of the Massachusetts Agricultural Experiment Station is in the same building the facilities it offers are also available. A greenhouse, where plants infested with injurious insects are under observation and experimental treatment, is also open to students. Photographic rooms with cameras and other photographic apparatus are provided, and the large greenhouses, gardens, orchards and grounds of the college offer further opportunities for the study of injurious insects under natural conditions.

Entomology. — *Beekeeping.* — For this work the main office, museum and lecture rooms are in the entomological building. There is also an apiary covering approximately two acres which will consist of about fifty colonies of bees in various types of hives and maintained for the several practical and experimental purposes. The apiary also includes a collection of nectar-yielding plants representative of the native flora as well as of the more important nectar sources from other localities. Especial opportunity is therefore given for a study of this fundamental problem of forage. Upon the apiary site is an eight-room building (the first in the world erected exclusively for teaching beekeeping) modeled to meet both the requirements of teaching and of a practical apiary. This building contains a boiler room, capacious wintering cellar, wax extraction room, general carpenter and work shop, laboratory, office, honey extraction room and stock room. The beekeeping equipment also includes an unexcelled collection of apicultural implements, natural history specimens and other curiosities. Practically every device used in American apiculture is available, it being the aim of the department to procure new inventions and implements as fast as they appear for the purpose of study and comparison. Available to the students is a private library of apicultural literature consisting of upwards of 900 volumes and papers, possibly the most complete collection in the country. This entire equipment is acknowledged unique in model and in completeness for the United States and for the world.

Farm Administration. — The college farm of 250 acres is under the general supervision of the Department of Farm Administration, and furnishes demonstration material. It includes improved land, pasture land and a farm wood lot. The improved land illustrates the value of good culture and the best known methods for the maintenance of fertility. The farm is equipped with suitable buildings and good machinery for the work carried on, of which the production of certified milk is an important branch. Several good farms in the vicinity, illustrating types of both special and general agriculture, may be inspected and studied. The offices of the department are in Stockbridge Hall.

Floriculture. — The Department of Floriculture aims to give the student a thorough knowledge of all phases in greenhouse design and construction and greenhouse heating, and in the culture of florists' crops. It is intended to train men for commercial floriculture and for the management of conservatories on private estates and parks and in cemeteries. The course is outlined to combine theoretical, technical and practical work in the most comprehensive manner possible. Probably no agricultural college has a Department of Floriculture better equipped than this. There has been erected a durable, practical, commercial range, composed of palm, fern, orchid, violet, carnation, rose and students' houses. French Hall, with its large laboratories, class rooms and offices, furnishes excellent facilities for the purposes of instruction. Besides the new glass houses, there are older houses suitable for growing bedding plants and chrysanthemums, and frames for the growing of annual and herbaceous perennial plants, violets and pansies. Many excellent specimens of trees and shrubs are growing on the college grounds, furnishing valuable material for the study of plant materials.

Forestry. — The Department of Forestry has an unusually complete equipment of the various instruments used in forest mensuration, forest mapping and engineering, timber estimating, log scaling, board measuring, etc.; a large assortment of boards illustrative of the various commercial woods found in the lumber markets. The State Forest Nursery, comprising 6 acres of land and containing, approximately, 5,000,000 trees, transplants and seedlings, is located on the college farm. Extensive forests containing every variety of tree common to New England are within walking distances of the college. The college campus affords an arboretum containing an exceptionally large number of trees not native to New England. The library contains complete sets of government bulletins, circulars, State reports and all the best books on forestry subjects.

Geology. — A large, well-lighted laboratory for geology, 27 by 50 feet, is in the basement of the new building for entomology, zoölogy and geology. This is equipped with cabinets, models, charts and a teaching collection of rocks. It has a seating capacity of 50 persons. Adjoining this is a smaller laboratory, 21 by 27 feet, for mineralogy, supplied with gas and cabinets for models, crystals and minerals. There is also a small laboratory for grinding thin sections, and a private laboratory, 6 by 19 feet, for analysis work. The geological museum is 27 by 48 feet. It has six large cases for exhibition purposes. The equipment for geology is being enlarged. At present, in addition to the general items mentioned above, it consists of a petrographic microscope, an illustrative series of thin sections, a small collection of invertebrate fossils, some casts of vertebrate fossils, a collection of the building stones of Massachusetts, and a duplicate set of the Edward Hitchcock survey collection of the rocks and minerals of Massachusetts.

HEATING, LIGHTING AND POWER. — The college supplies its own light, heat and power, including electricity for the night lighting of the campus and its approaches. The machinery of the barn, the dairy and other buildings is operated by electricity generated at the power-house. The college has also a machine shop and well-equipped carpenter shop.

LANDSCAPE GARDENING. — The work in landscape gardening is developed in a strong technical four-year course; the first two years are occupied with required studies, including botany, horticulture, surveying and mathematics, and the last two years are devoted to more specialized studies in landscape gardening, arboriculture, floriculture, entomology, botany and mathematics. The environment is unusually favorable. The strictly technical work in landscape gardening is taught in light and comfortable drafting rooms, fully furnished with instruments and accessories for thorough work. There is a well-selected library, and the equipment of surveying and drafting instruments is unusually complete and practical.

LIBRARY. — The library — stack room, reading room and office — occupies the entire lower floor of the Chapel-library building. It contains nearly 50,000 volumes and a large number of pamphlets, hitherto inaccessible, but which are being put into good working order as fast as possible. Works of a scientific character predominate, but economics, literature and history are well represented and are receiving due attention. The reading room provides a variety of periodical literature, both technical and popular, encyclopedias and general reference books.

The library is now being reclassified and recatalogued, to make the splendid collection of material here gathered together readily accessible and of the greatest working value. Every effort is being made toward developing the library into a vital intellectual center of college life, of equal value to every student, teacher and teaching department. In consequence, only the most cordial relations are cherished, and the fewest and most imperative rules concerning the circulation of books and deportment are enforced.

Lectures are given to regular and short-course students to enable them to make the best use of the library. Emphasis is laid upon the proper use of the card catalogue, periodical indexes, bibliographies and guides; also, in general, assigned and class-room work, and essay and debate work.

The library hours are from 7.30 A.M. to 9.30 P.M. every week day, and from 9 A.M. to 2 P.M. on Sundays, in term time. Shorter hours prevail during vacation.

MARKET GARDENING. — The purpose of the courses in market gardening is to acquaint the student with the theories and practice of market gardening so that he will be able to carry on the business intelligently. The equipment available for practical work consists of 10 acres of good gardening land; a large collection of horse and hand garden tools; hot-beds and cold-frames; and lettuce, cucumber and tomato houses. The students therefore have opportunity both to study and to practice the important branches of the business. Classes are taught in French Hall, a new building fitted with class rooms and laboratory particularly equipped for market gardening. A good library of works on vegetable gardening is available.

MATHEMATICS AND CIVIL ENGINEERING. — *Surveying.* — The department has a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by doing field work. Among the larger instruments are 2 plain compasses, a railroad compass with telescope, a surveyor's transit, 3 engineer's transits with vertical arc and level, a Brandis solar transit, a solar compass, an omnimeter with verniers reading to 10 seconds, adapted to geodetic work, a Queen plane table, 3 wye levels, 2 dumpy levels, a builder's level, a sextant, a hand level, and a large assortment of leveling rods, flag poles, chains, tapes, etc. For drafting, a vernier protractor, a pantograph, a parallel rule, etc., are available. The department also has a Fairbanks cement testing outfit.

MILITARY SCIENCE. — This department makes use of the campus for battalion drill, and has a special building in which there is a drill room 60 by 135 feet, an armory, an office for the commandant, a field-gun and gallery practice room and a large bathroom. The national government supplies Krag-Jorgensen rifles, with complete equipments and ammunition. The State supplies instruments for the college band. Students are held responsible for all articles of public property in their possession. The college owns an excellent target range for rifle practice, lying a short distance out of the village.

PHYSICAL EDUCATION. — The gymnasium and armory has a floor space of 5,000 square feet, and is 30 feet high, well lighted and ventilated. The main floor is used for basket ball, indoor baseball and hand ball. The gallery has been fitted up as a special exercise and gymnastic room, and is equipped with modern developing apparatus, including parallel bars, horses, bucks, chest weights, dumb-bells, Indian clubs and striking bags. An outdoor board track enables students to secure track practice through the winter, and two ice hockey rinks give ample opportunity for hockey practice. Credit is given to all students taking part in outdoor activities. "Treks" are held twice a week, and whenever possible snowshoe and skiing hikes are also held. Steel lockers and bathrooms have been installed in North and South colleges, and the gymnasium has been fitted with a shower-room. The gymnasium classes are held the last two hours in the morning and the last two hours in the afternoon, but students may use the gymnasium at other times for exercise purposes by arrangement with the department. The regulation costume for class exercise consists of a white track suit and white rubber-sole shoes.

PHYSICS. — Among the apparatus in use for instruction in general physics are a set of United States standard weights and measures, precision balances, a spherometer, vernier calipers, a projection lantern, etc.; in mechanics, a seconds clock, systems of pulleys and levers, and apparatus to illustrate the laws of falling bodies and motion on an inclined plane, and the phenomena connected with the mechanics of liquids and gases. The department is equipped with the usual apparatus for lecture illustration in heat, light and sound; in electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, including a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, a Mascart quadrant electrometer, a Siemens electro-dynamometer, and reflecting galvanometers and Wheatstone bridges for ordinary determinations of currents and resistances.

POMOLOGY. — The Department of Pomology has 45 acres of orchard, including apple, pear, peach, plum, cherry and quince trees. Of particular interest is the large collection of these fruits on the various dwarf stocks, showing many types of training. The recent revival of interest in dwarf fruits makes these dwarf orchards of especial value to students. There are also two commercial vineyards, and a smaller one in which are shown the principal types of trellis and the leading methods of training grapes. Several acres are used in growing the various kinds of small fruits, such as strawberries, raspberries, blackberries, currants and gooseberries. There are also nurseries, where all of these various types of fruits are grown, in which students may see them in all stages of development.

The department has a good equipment of orchard and nursery tools of all the principal types, the use of which enables students to learn the value of each type. For other orchard operations, such as spraying and pruning, the most approved makes of pumps, nozzles, pruning saws, knives, etc., are provided. For laboratory work in systematic pomology there is a collection of more than 100 wax models of apples, plums, pears and peaches, in natural colors, which are particularly valuable in identifying varieties of these fruits unknown to the student. The laboratory is also furnished with a large number of reference books on pomology; and fruit in a fresh condition is available in great variety, not only from the college orchards but from other parts of Massachusetts and from many other States. In 1912–13, for instance, apples for class use were received from Idaho, Missouri, Utah, Washington, Maine, Connecticut, Pennsylvania, Montana, Minnesota, Nebraska, Kentucky, Iowa, Wisconsin, Michigan, New York, Kansas, Colorado, Oregon, New Jersey and Vermont, besides collections of grapes from California and citrus fruit from Florida and Texas. From the college fruit plantations the following fruits were available: grapes, fifty varieties, representing three native American species and several hybrids; twenty varieties of peaches, twenty varieties of pears, twenty-five varieties of plums, eighty varieties of apples.

Poultry Husbandry. — The poultry plant consists of about 9 acres of land sloping gently to the west. The soil is a fine, rich, sandy loam, well drained. At present the buildings consist of an incubator cellar, 22 by 34 feet, with a capacity of 4,000 eggs, over which is a demonstration building; a pipe brood house (open-pipe system), 14 by 72 feet, which will accommodate 1,200 chickens; a long laying house, 14 by 180 feet, which accommodates 500 layers and furnishes facilities for student work in pen management; a laboratory, 14 by 80 feet, for killing, picking, dressing, crate fattening, cramming, etc.; a storage building, 28 by 42 feet, for experimental incubation, poultry carpentry, poultry mechanics and storage; an experimental breeding house, 18 by 60 feet; a combination laying, testing and breeding house, 18 by 72, for experimental purposes, and a model laying house, 18 by 30, for 100 hens; the 6 old experiment-station buildings, each 12 by 18 feet, to be used as breeding houses; 14 colony houses; 8 growing crops; a manure shed, 14 by 18 feet; and an oil house, 10 by 12 feet. Instruction in this department is given in the form of lectures, demonstrations and practical work. The practical work consists of poultry carpentry, caponizing, killing, picking, dressing, packing and selling poultry; pen management and fattening; running incubators and brooders, etc. At present the stock consists of 20 leading varieties of poultry. The aim of the department is to keep good specimens of all the most popular varieties of chickens, ducks and geese, so that a thorough course in poultry judging may be given, and that visitors may find the inspection of our stock an education in itself.

PUBLIC SPEAKING. — In connection with the work in public speaking, three regular contests are held during the year. The Burnham contest in declamation is open to freshmen and sophomores; the Flint contest in oratory and the annual debating contest are open (under restrictions) to all regular students. These contests offer a very practical and necessary experience to all students interested in improving themselves in the art of public speaking. Prizes are given for excellence in the contests. Intercollegiate contests are arranged by the Public Speaking Council. One credit is given, except to freshmen, for a year of work in the College Debating Club.

RURAL ENGINEERING. — This department has an office and the use of a lecture room in Stockbridge Hall. The work on farm structures is given in the large drawing room in the same building. This room is fitted with thirty drawing tables. Models and blue prints are available for the study of farm buildings.

The work on farm machinery and farm motors is given in the Rural Engineering building. This is a one-story structure 34 by 68 feet. The equipment includes gasoline engines and pumps and a complete line of farm field machines. A small dynamo and switchboard are used in the study of farm lighting systems. The study of post molds and a machine for making cement tile afford opportunity for practical work with cement.

The work on the small field machines is given in the basement of Stockbridge Hall.

Work on steam engines and steam heating is given in Flint Laboratory.

RURAL JOURNALISM. — The news-room, or laboratory, for the courses in rural journalism, is equipped with typewriting machines, copy tables, representative newspapers, reviews, agricultural papers, and trade journals concerning journalism and writing, selected books on journalism, reference books, and a considerable "morgue" of indexed pamphlets and monographs on farming, rural life and rural industry (loan collection). The news-room is in the recently completed Stockbridge Hall, with the division library of the Division of Agriculture, and is kept open until 10 P.M.

VETERINARY SCIENCE. — The Department of Veterinary Science occupies a modern laboratory and hospital stable, built in accordance with the latest principles of sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The main building contains a large working laboratory for student use, and several small private laboratories for special work. There is a lecture hall, a museum, a demonstration room, a photographing room and a workshop. The hospital stable contains a pharmacy, an operating hall, a post-mortem and dissecting room, a poultry section, a section for cats and dogs, and 6 sections, separated from each other, for horses, cattle, sheep and swine. The laboratory equipment consists of a dissectible Auzoux model of the horse and Auzoux models of the foot and the leg, showing the anatomy and the diseases of every part. The laboratories also have modern, high-power microscopes, microtomes, incubators and sterilizers, for work in every department of veterinary science including pathology, serology and parasitology. There are skeletons of the horse, the cow, the sheep, the dog and the pig, and a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams.

Zoölogy. — The college offers increased facilities for the study of zoölogy. In the new building for entomology, zoölogy and geology are spacious laboratories for both undergraduate and graduate work. On the first floor is a large sophomore laboratory, 27 by 100 feet, with a present seating capacity of 100 persons. Adjoining this is a smaller room, 20 by 27 feet, for junior and senior courses. All laboratories are equipped with gas. The equipment consists of 80 compound microscopes and accessories, 70 dissecting microscopes, microtomes and accessories, paraffine baths, incubator, dissecting instruments, glassware and other necessary apparatus.

The large amphitheater lecture hall is used jointly by the Departments of Entomology and Zoölogy-Geology. It is equipped with charts and models. The zoölogical museum is drawn upon at all times for illustrative material. The zoölogical museum is 27 by 48 feet. The main room is on the first floor of the building. Above this, on a level with the second floor, is a large gallery. On the main floor are 8 large wall cases and 5 large floor cases for exhibition purposes. The gallery has 1 large wall case and 3 floor cases with space for 9 additional cases. The zoölogical collection consists of nearly 12,000 specimens. All the chief phyla are represented. Adjoining the museum is a preparator's room for the curator. The museum is open to the public from 1 to 5 P.M. on Saturdays, and on other week days from 3 to 6 P.M. The curator is Associate Professor Gordon.

LIST OF AWARDS AND PRIZES, 1915.

Grinnell Prizes. — The Grinnell prizes, given by the Hon. William Claflin of Boston in honor of George B. Grinnell, Esq., of New York, to those members of the senior class who pass the best, second best and third best examinations, oral and written, in theoretical and practical agriculture, were awarded as follows: —

First prize, $25, awarded to Philip Ferry Whitmore.

Second prize, $15, awarded to Ralph P. Hotis.

Third prize, $10, awarded to Waldo Atwood Cleveland.

General Improvement. — The Western Alumni Association prize, given to that member of the sophomore class who, during the first two years in college, has shown the greatest improvement in scholarship, character and example, was $25. Awarded to Daniel Johnston MacLeod.

Hills Botanical Prizes. — Hills prizes for the best and second best herbarium, competition open to members of the senior, junior and sophomore classes, were awarded as follows: —

First prize of $20 awarded to Ernest Elwood Stanford of the senior class.

Second prize of $15 awarded to Dana Otis Merrill of the sophomore class.

Public Speaking (previously announced). — The Burnham prizes were awarded to the students delivering the best and second best declarations, as follows: —

First prize, $15, awarded to N. N. Worthley, 1918.

Second prize, $10, awarded to L. E. Wolfson, 1918.

The Flint prizes were awarded to the students delivering the best and second best orations, as follows: —

First prize, $20, awarded to H. L. Russell, 1918.

Second prize, $15, awarded to L. D. Kelsey, 1917.

Interclass Debate. — Won by the Freshman Debating Team, composed of D. M. Lipshires, $15, H. L. Russell, $15, and L. E. Wolfson, $15.

Prize College Debate. — H. K. Foster, 1918, D. M. Lipshires, 1918, and H. L. Russell, 1918, — silver cup to each.

Military Honors. — The following-named cadet officers have been reported to the Adjutant-General of the United States army and to the Adjutant-General of the Commonwealth of Massachusetts as being efficient in military science and tactics and graduating therein with highest honors: —

Cadet Col. D. J. Lewis.
Cadet Maj. P. F. Whitmore.
Cadet Maj. A. E. Wilkins.
Cadet Capt. E. C. Towne.
Cadet Capt. H. H. White.
Cadet Capt. R. W. Harvey.
Cadet Capt. A. J. Flebut.
Cadet Capt. S. K. Farrar.
Cadet Capt. M. J. Clough.
Cadet Capt. R. E. McLain.
Cadet Capt. G. F. Hyde.
Cadet Capt. H. D. Grant.

SECRETARIES OF ALUMNI ASSOCIATIONS.

Associate Alumni of the Massachusetts Agricultural College.
Secretary: Dr. Charles A. Peters, 1897, Amherst, Mass.

Alumni Secretaries' Association of the Massachusetts Agricultural College.
Secretary: Ralph J. Watts, 1907, Amherst, Mass.

Alumni Club of Massachusetts.
Secretary: P. W. Pickard, 1911, 43 Chatham Street, Boston, Mass.

Connecticut Valley Association of the Massachusetts Agricultural College.
Secretary: Paul E. Alger, 1909, Great Barrington, Mass.

Massachusetts Agricultural College Club of New York.
Secretary: Dr. John Ashburton Cutter, 1882, 266 West 77th Street, New York, N. Y.

Massachusetts Agricultural College Club of Washington, D. C.
Secretary: Dr. William A. Hooker, 1900, U. S. D. A., Office of Experiment Stations, Washington, D. C.

Western Alumni Association of the Massachusetts Agricultural College.
Secretary: Charles A. Tirrell, 1906, 815 Steinway Hall, Chicago, Ill.

Massachusetts Agricultural College Pacific Coast Alumni Association.
Secretary: Thomas F. Hunt, 1905, Berkeley, Cal.

Massachusetts Agricultural College Club of Hawaii.
Secretary: Dr. E. A. Back, 1904, Honolulu, T. H.

Class Secretaries.

Class of	SECRETARY.	Secretary's Address.
1871	E. E. Thompson, .	5 Jacques Avenue, Worcester, Mass.
1872	F. E. Kimball, . .	8 John Street, Worcester, Mass.
1873	C. Wellington, . .	Amherst, Mass.
1874	D. G. Hitchcock, .	Warren, Mass.
1875	– –	– –
1876	C. Fred Deuel, . .	Amherst, Mass.
1877	Atherton Clark, .	231 Waverley Avenue, Newton, Mass.
1878	C. O. Lovell, . .	201 Darke Block, Regina, Saskatchewan, Can.
1879	R. W. Swan, . .	41 Pleasant Street, Worcester, Mass.
1880	Alvan L. Fowler, .	413 Post Office Building, Philadelphia, Pa.
1881	J. L. Hills, . .	59 North Prospect Street, Burlington, Vt.
1882	G. D. Howe, . .	25 Winter Street, Bangor, Me.
1883	J. B. Lindsey, . .	Amherst, Mass.
1884	E. A. Jones, . .	New Canaan, Conn.
1885	E. W. Allen, . .	1923 Biltmore Street, Washington, D. C.
1886	Winfield Ayres, . .	616 Madison Avenue, New York City.
1887	F. H. Fowler, . .	Shirley, Mass.
1888	H. C. Bliss, . .	14 Mechanic Street, Attleboro, Mass.
1889	F. W. Davis, . .	85 Colberg Avenue, Roslindale, Mass.
1890	David Barry, . .	398 Walnut Street, Newtonville, Mass.
1891	H. T. Shores, . .	177 Elm Street, Northampton, Mass.
1892	H. M. Thomson, .	Amherst, Mass.
1893	F. A. Smith, . .	Hathorne, Mass.
1894	S. F. Howard, . .	Northfield, Vt.
1895	E. A. White, . .	Ithaca, N. Y.
1896	A. S. Kinney, . .	South Hadley, Mass.
1897	C. A. Peters, . .	Amherst, Mass.
1898	W. S. Fisher, . .	Peace Street Grammar School, Providence, R. I.
1899	D. A. Beaman, . .	Rio Piedras, Porto Rico.
1900	E. K. Atkins, . .	15 Hubbard Avenue, Northampton, Mass.
1901	J. H. Chickering, .	Dover, Mass.
1902	H. L. Knight, . .	1420 Buchanan Street, Washington, D. C.
1903	G. D. Jones, . .	North Amherst, Mass.
1904	P. F. Staples, . .	Sherborn, Mass.
1905	A. D. Taylor, . .	1900 Euclid Avenue, Cleveland, O.
1906	Richard Wellington, .	St. Anthony Park, Minnesota.
1907	Clinton King, . .	31 Elm Street, Springfield, Mass.
1908	S. T. Wright, . .	17 Camp Street, Norwalk, Conn.
1909	O. B. Briggs, . .	1015 Fidelity Building, Baltimore, Md.
1910	F. L. Thomas, . .	Auburn, Ala.
1911	L. M. Johnson, . .	Newtown, Conn.
1912	F. S. Madison, . .	East Greenwich, R. I.
1913	B. W. Ellis, . .	Bournedale, Mass.
1914	L. Ernest Smith, .	Colchester, Conn.
1915	P. F. Whitmore, .	Sunderland, Mass.

DEGREES CONFERRED AND ROLL OF STUDENTS.

DEGREES CONFERRED — 1915.

DOCTOR OF PHILOSOPHY (Ph.D.).

Holland, Edward Bertram, Amherst, Mass., Massachusetts Agricultural College, M.Sc.
Hutson, John Coghlan, Barbados, W. I., Massachusetts Agricultural College, M.Sc.
Martin, James Francis, Amherst, Mass., Massachusetts Agricultural College, M.Sc.
Parker, Ralph Robinson, Malden, Mass., Massachusetts Agricultural College, M.Sc.
Regan, William Swift, Northampton, Mass., Massachusetts Agricultural College, B.Sc.

MASTER OF SCIENCE (M.Sc.).

Bogue, Robert Herman, North Amherst, Mass., Tufts College, B.Sc.
Brown, Henry Leavitt, Ayer, Mass., University of Maine, B.Sc.
Hasey, Willard Harrison, Brockton, Mass., Massachusetts Agricultural College, B.Sc.
Norton, John Buck, Hartford, N. Y., University of Vermont, B.Sc.
Root, George Albert, Danbury, Conn., Connecticut Agricultural College, B.Sc.

BACHELOR OF SCIENCE (B.Sc.).

Alden, Charles Harold,	Amherst.
Allen, Francis Ellwood,	Melrose.
Archibald, Herbert Hildreth,	Waltham.
Banister, Seth Warrener,	Westford.
Bartlett, Edward Russell,	Newburyport.
Bartley, Hastings Newcomb,	Sandwich.
Bemis, Willard Gilbert,	North Brookfield.
Bennett, John Ingram,	Boston.
Bishop, Chester Allen,	Peterboro, N. H.
Brooks, Gardner Milton,	Boston.
Buell, Frank Weed,	New Haven, Conn.
Burt, Helen Frances,	West Somerville.
Buttrick, John Willard,	Melrose.
Cale, Gladstone Hume,	Springfield.
Cande, Donald Hopkins,	Pittsfield.
Chase, Alexander Baxter, Jr.,	West Barnstable.
Clark, Ellis Fred,	Granby, Conn.
Cleveland, Waldo Atwood,	Baldwinsville.
Clough, Maurice Joseph,	Boston.
Dalrymple, Andrew Campbell,	Revere.
Damon, Leon Blanchard,	Melrose.
Day, George Allen,	Warren.
Dole, Sumner Alvord,	Shelburne.
Doran, William Leonard,	North Dartmouth.
Draper, Earle Sumner,	Milford.
Farrar, Stuart Kittridge,	Springfield.
Fitzgerald, Daniel James,	Worcester.
Flebut, Alpha John,	Amherst.
Frost, Robert Theodore,	New York, N. Y.
Fuller, Richard,	Salem.
Goodwin, Malcolm Noyes,	Newburyport.
Grant, Harold Davidson,	Methuen.
Griggs, Raymond Bradford,	Chicopee Falls.
Hall, George Morris,	Brookline.
Hall, Roderick Chesley,	Worcester.
Harper, James Edward,	New Haven, Conn.
Harvey, Russell Wilton,	Lanesville.

Haskell, Willis Henry, Jr.,	Brooklyn, N. Y.
Hatfield, William Hollis,	Wellesley.
Hildreth, Paul Hughes,	Newtonville.
Hotis, Ralph P.,	Evans Mills, N. Y.
Hyde, George Frederick,	Hartford, Conn.
Hyde, Harold Gilmore,	Winchendon.
Johnson, Arthur,	Bridgeport, Conn.
Kelleher, Jerome Joseph,	Turners Falls.
Kennedy, Worthington Chester,	Hardwick.
Lane, Merton Chesleigh,	South Duxbury.
Le Duc, Ashley Cudworth,	Chesterfield.
Lewis, Daniel James,	Hanson.
Lewis, John Kirby,	New Haven, Conn.
Lincoln, Irving Boin,	Glens Falls, N. Y.
Lovejoy, John Sumner,	Newburyport.
MacNeil, Ralph Langdel,	Chelsea.
Macy, Philip Arthur,	Oak Bluffs.
Marsh, Franklin Winter,	Amherst.
Marsh, Herbert Verner,	Deerfield.
Massé, Sidney Merton,	Dorchester.
McKechnie, Ray Farrar,	Natick.
McLain, Ralph Emerson,	Melrose.
Melican, George Deady,	Worcester.
Moberg, Eldon Samuel,	Campello.
Montague, Enos James,	Northampton.
Moore, Roger Henry,	Beverly.
Navas, Miguel,	Barranquilla, Colombia, S. A.
Parker, Edwin Kenney,	Northampton.
Parmenter, Ernest Brigham,	Franklin.
Patterson, Robert Earley,	Dorchester.
Pendleton, Harlow Libby,	Dorchester.
Perry, Gerald Eugene,	Amherst.
Pike, Joseph Stevens, Jr.,	Somerville.
Potter, George Raymond,	Ludlow.
Price, James Albert,	New York, N. Y.
Rhoades, Paul Whitney,	Malden.
Rogers, Harold Merriman,	Southington, Conn.
Sauchelli, Vincent,	Waterbury, Conn.
Sears, William Richard,	Woburn.
Severance, Verne Lincoln,	South Hanson.
Sherman, Milton Francis,	South Lincoln.
Simon, Isaac Barney,	Revere.
Slein, Owen Francis,	New Braintree.
Smith, Hyde,	Worcester.
Spicer, Eber Grant,	New York, N. Y.
Spofford, Chester Porter,	South Groveland.
Stanford, Ernest Elwood,	Amherst.
Tarr, Lester Winslow,	Rockport.
Tower, Ralph Ernest,	Becket.
Tower, William Reginald,	Sheffield.
Towne, Edwin Chester,	Waltham.
Upton, Raymond Melville,	Peabody.
Vener, Benjamin,	Brockton.
Vinal, Stuart Cunningham,	Boston.
Walker, Herman Chester,	Holyoke.
Wellington, Benjamin,	Waltham.
White, Henry Harrison,	West Peabody.
Whitmore, Philip Ferry,	Sunderland.
Whorf, Paul Francis,	Caribou, Me.
Wilkins, Alfred Emerson,	Wakefield.
Willey, Harold Cleland Clancey,	Orange.
Williams, Donald,	Catasauqua, Pa.
Wright, Elvin Stanley,	Worcester.
Zehrung, Samuel Danford,	Roseville, O.

ROLL OF STUDENTS.

GRADUATE STUDENTS — CANDIDATES FOR A DEGREE.

Anderson, David Wadsworth, B.Sc., New Hampshire State College.	Manchester, N. H.
Armstrong, Robert Pierson, B.Sc., Massachusetts Agricultural College.	Rutherford, N. J.
Avery, Roy Crowdy, B.Sc., Connecticut Agricultural College.	New York City.
Baird, Charles Glenn, A.B., University of Kansas; A.M., University of Wyoming.	Powell, Wyo.
Bales, Harold C., A.B., Dartmouth College.	North Amherst.
Beals, Carlos Loring, B.Sc., Massachusetts Agricultural College.	Amherst.
Bourne, Arthur Israel, A.B., Dartmouth College.	Amherst.
Bronson, Wesley Hotchkiss, B.Sc., New York State College of Agriculture.	Amherst.
Chapman, George Henry, B.Sc. and M.Sc., Massachusetts Agricultural College.	Amherst.
Christopher, Paul F., B.Sc., Colby College.	Hadley.
Clapp, Raymond K., B.Sc., Massachusetts Agricultural College.	Easthampton.
Cobb, J. Stanley, B.Sc., Cornell University.	Groton, N. Y.
Copson, Godfrey V., B.Sc. in agriculture, Oregon Agricultural College.	Corvallis, Ore.
Davies, Ernest Langford, B.Sc., Ontario Agricultural College.	Guelph, Can.
Doran, William Leonard, B.Sc., Massachusetts Agricultural College.	North Dartmouth.
Erichsen, Alexander J., B.Sc., Pennsylvania State College.	Atlantic City, N. J.
Fish, Ernest Ellsworth, B.Sc., Pennsylvania State College.	Wyalusing, Pa.
Flebut, Alpha John, B.Sc., Massachusetts Agricultural College.	Amherst.
Hood, Egerton Gibson, B.Sc.A., Ontario Agricultural College.	Hagermon, Ontario, Can.
Itano, Arao, B.Sc., Michigan Agricultural College.	Okayamaken, Japan.
Johnson, Leonard H., B.S. in agriculture, Purdue University.	Monticello, India.
Lund, Russell Fort, B.A., St. Lawrence University.	Amherst.
MacDougall, Allister F., B.Sc., Massachusetts Agricultural College.	Northampton.
MacNeil, Ralph Langdel, B.Sc., Massachusetts Agricultural College.	Chelsea.

McKechnie, Ray F., B.Sc., Massachusetts Agricultural College.	Natick.
Merkle, Frederick Grover, B.Sc., Massachusetts Agricultural College.	Amherst.
Morgan, Ezra L., A.B., McKendree College; M.A., University of Wisconsin.	Amherst.
Mutkekar, Satwaji Gundoji, B.Agr., Poona Agricultural College.	Belgaum, Ind.
Payne, William Thomas, Oklahoma Agricultural and Mechanical College.	Oklahoma City, Okla.
Peckham, Curtis, B.Sc., Massachusetts Agricultural College.	New Bedford.
Perry, Gerald Eugene, B.Sc., Massachusetts Agricultural College.	Amherst.
Phillips, Arthur W., B.Sc. in chemistry, Tufts College.	Somerville.
Porter, Bennett Allen, B.Sc., Massachusetts Agricultural College.	Amherst.
Read, Frederick W., B.Sc., Massachusetts Agricultural College.	Boston.
Root, Irving C., B.Sc., Kansas State Agricultural College.	Kansas City, Kan.
Ruprecht, Rudolph W., B.Sc. and M.Sc., Massachusetts Agricultural College.	Flatbush, N. Y.
Serex, Paul, Jr., B.Sc., Massachusetts Agricultural College.	Amherst.
Smith, Raymond Goodale, B.Sc., Massachusetts Agricultural College.	Lynn.
Strand, Carl J., A.B., Augustana College; M.S., University of Illinois.	Amherst.
Taylor, Leland H., B.Sc., Massachusetts Agricultural College.	Peabody.
Thurston, Arthur S., B.Sc., Massachusetts Agricultural College.	Everett.
Vinal, Stuart C., B.Sc., Massachusetts Agricultural College.	East Weymouth.
White, Donald, A.B., Harvard College.	Wakefield.
White, Edward Albert, B.Sc., Massachusetts Agricultural College.	Ithaca, N. Y.

Graduate Students — not Candidates for a Degree.

Emery, Barton C., A.B., Bowdoin College.	Amherst.
Fenn, Donald F., A.B., Harvard College.	Cambridge.
Harris, Margaret, A.B., Wellesley College.	Deerfield.
Karlson, Hugo P., A.B., Clark College.	Orange.
Lovejoy, John Sumner, B.Sc., Massachusetts Agricultural College.	Newburyport.
Middleton, Frederick Heard, A.B., Harvard University.	Brookline.
Morgan, Denison, A.B., Yale University.	New Haven, Conn.
Porter, Margaret Love, M.A., Columbia University.	Amherst.

SENIOR CLASS.

Aiken, Harold,	Millis,	Lambda Chi Alpha.
Anderson, Frank Albert,[1]	Somerville,	Phi Sigma Kappa.
Andrews, Francis Marshall, Jr.,	Manchester,	53 Lincoln Avenue.
Barnes, Dwight Fletcher,	Bedford,	East Experiment Station.
Barnes, Fred Leslie Walker,[1]	Plymouth,	16 South College.
Bishop, Herbert Walker,	Doylestown, Pa.,	Alpha Sigma Phi.
Blanpied, Nelson Uhler,	Framingham,	13 South College.
Boyer, Edward Everett Hale,[1]	Lynn,	5½ East Pleasant Street.
Brazil, William Henry,	Leominster,	12 South College.
Caldwell, Harold Nute,[1]	Lowell,	M. A. C. Farm House.
Cardarelli, Emilio Joseph,	Boston,	West Experiment Station.
Chase, Esther Helen,	Holden,	Draper Hall.
Chisholm, Raymond Lincoln,	Melrose Highlands,	Phi Sigma Kappa.
Clapp, Raymond Luckey,	Northfield,	11 South College.
Clark, Saxon Dickinson,	Springfield,	2 South College.
Coe, Alfred Lynn,	Fayetteville, N. Y.,	Beta Kappa Phi.
Coleman, Albert Sumner,	Mendon,	11 South College.
Coley, William Stanton,[1]	Wilton, Conn.,	15 North College.
Courchene, Alcide Telesphor,[1]	North Adams,	Mount Pleasant.
Curran, Harry Ambrose,	Marlborough,	2 North College.
Cushing, Raymond Alonzo,[1]	West Somerville,	14 South College.
Danforth, George Newlon,[1]	Foxcroft, Me.,	Kappa Sigma.
Darling, Homer Chester,	Mendon,	7 South College.
Davis, Frank Leslie,	Milford,	South College.
Dickinson, William Cowls,	North Amherst,	North Amherst.
Dodge, Walter Eugene,	Geneva, O.,	14 South College.
Eldredge, Raymond Chase,	North Abington,	2 South College.
Estes, Ralph Cary,[1]	South Framingham,	15 South College.
Fernald, Charles Henry, 2d,	Amherst,	44 Amity Street.
Fielding, Lester Edward,[1]	Malden,	1 South College.
Gaventa, Harry Reymer,	Swedesboro, N. J.,	11 North College.
Gilmore, Benjamin Anthony,	Acushnet,	Beta Kappa Phi.
Gioiosa, Alfred Anthony,	Dorchester,	Alpha Sigma Phi.
Glover, Theodore Whitford,	South Duxbury,	Lambda Chi Alpha.
Goodwin, Clinton Foster,	Haverhill,	Lambda Chi Alpha.
Googins, Burton,	Amherst,	Baker Place.
Gould, Charles Holt,	Hubbardston,	Theta Chi.
Gunn, Carlton Merrick,	Sunderland,	Beta Kappa Phi.
Hager, Clayton Marden,	Somerville,	13 South College.
Hall, Stanley William,	Saxonville,	3 South College.
Harris, William Lombard, Jr.,	Deerfield,	53 Lincoln Avenue.
Harrocks, Thomas Lincoln,	Westminster,	15 North College.
Hart, Reginald,	Montague City,	10 North College.
Haskell, Frank Eugene,	Northborough,	11 North College.
Hathaway, Charles Edward, Jr.,	Somerset,	13 South College.
Hemenway, Justin Stanley,	Williamsburg,	9 North College.
Hendry, Arthur Ekman,[1]	Milton,	M. A. C. Apiary.
Hicks, Albert James,	Amherst,	4 Chestnut Street.
Holden, Mae Faustina,	Royalston,	Draper Hall.
Hunt, Reginald Stuart,[1]	Newtonville,	2 South College.
Huntington, Charles Albert, Jr.,	Poquonock, Conn.,	Kappa Sigma.
Jerome, Fred William,	Stockbridge,	9 South College.
Jones, Linus Hale,	Milford,	Mount Pleasant.
Jordan, Perley Balch,	Topsfield,	14 South College.
Kelly, Harold Russell,	Haverhill,	Pease Avenue.
Kilbon, Ralph Gillette,	Springfield,	4 South College.
King, Edward Lee,	Norwood,	8 South College.
Knapton, Guy Lord,[1]	Lawrence,	Pease Avenue.
Laird, Kenneth Bradford,	Brockton,	79 Pleasant Street.

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[1] Work incomplete.

Lieber, Conrad Hugo,	Jamaica Plain,	3 North College.
Lindquist, Albert Evert,	Roxbury,	3 North College.
Little, Harold Greenleaf,	Newburyport,	4 South College.
Locke, Wilbur Trow,	Lawrence,	Alpha Sigma Phi.
Lyford, Waldo Preston,	Natick,	13 South Prospect Street.
Mahan, Harold Butterworth,	Manchester, N. H.,	15 South College.
Mattoon, Harold Gleason,[1]	Pittsfield,	12 South College.
Mooney, Raymond Alson,	Plattsburgh, N. Y.,	Alpha Sigma Phi.
Moses, Charles Wicker,	Ticonderoga, N. Y.,	3 South College.
Mostrom, Harold Augustus,	North Middleborough,	10 Nutting Avenue.
Murphy, John William,	Beverly,	Phi Sigma Kappa.
Nash, Clayton Wells,	South Weymouth,	12 North College.
Nicholson, James Thomas,[1]	Leominster,	12 South College.
Palmer, George Bradford,	Brookline,	3 South College.
Perry, Edgar Adams,	Attleboro,	Alpha Sigma Phi.
Plaisted, Philip Asbury,	Arlington,	Phi Sigma Kappa.
Potter, David,	Concord,	20 South College.
Prouty, Stanley Marshall,	North Brookfield,	Kappa Sigma.
Ray, George Burrill,	Hingham,	3 North College.
Rich, Gilbert Warren,[1]	Hingham,	15 South College.
Richards, Everett Stackpole,	Hatfield,	1 South College.
Ricker, Dean Albert,[1]	Worcester,	7 North College.
Rogers, Tyler Stewart,	Framingham,	Phi Sigma Kappa.
Rowe, Louis Victor,[1]	Melrose,	16 South College.
Russell, Ernest Samuel,	South Hadley,	Kappa Sigma.
Ryan, William Edward, Jr.,	Stoughton,	12 North College.
Sander, Benjamin Charles Louis,	Cambridge,	Theta Chi.
Sanderson, Everett Shovelton,	Centreville, R. I.,	12 North College.
Scheufele, Frank Joseph,	South Natick,	Phi Sigma Kappa.
Schlotterbeck, Lewis,	Roxbury Station, Conn.,	Alpha Sigma Phi.
Selkregg, Edwin Reimund,[1]	North East, Pa.,	10 South College.
Sherinyan, Donald Suran,[1]	Los Angeles, Cal.,	5 North College.
Simmons, Perez,	Pittsfield,	Lambda Chi Alpha.
Stearns, Frederick Campbell,[1]	Waltham,	10 North College.
Strauss, Abraham,	Roxbury,	Clark Hall.
Swan, Durelle,	Dorchester,	18 Nutting Avenue.
Taber, Ralph Fred,	Cooperstown, N. Y.,	Mount Pleasant.
Topham, Alfred,[1]	Lawrence,	13 North College.
Upham, Thomas Carlton,	Fitchburg,	53 Lincoln Avenue.
Verbeck, Howard Graves,	Malden,	Phi Sigma Kappa.
Walkden, Herbert Halden,	Westford,	2 North College.
Walker, Henry Marshall,[1]	Brookline,	2 North College.
Wentworth, Everett Lawrence,	East Dover, Vt.,	M. A. C. Plant House.
Wetherbee, Raymond Scott,	Waltham,	11 North College.
Whitney, Harold Tichenor,[1]	Mount Vernon, N. Y.,	7 North College.
Whitney, Leon Fradley,	Brooklyn, N. Y.,	Kappa Sigma.
Wies, Calmy,	Malden,	31 Pleasant Street.
Wildon, Carrick Earl,	Melrose Highlands,	14 North College.
Woolley, Harold Curtis,[1]	Malden,	4 South College.

JUNIOR CLASS.

Babcock, Philip Rodney,[1]	Lynn,	Kappa Sigma.
Barnes, Herbert Wesley,	Whitinsville,	Commons Club.
Behrend, Oswald,	Natick,	Commons Club.
Bell, Alfred Whitney, Jr.,[1]	West Newton,	53 Lincoln Avenue.
Birchard, John Dixon,[1]	Springfield,	Phi Sigma Kappa.
Boles, Robert Stewart,	Dorchester,	Beta Kappa Phi.
Bonn, Wesley Copeland,	Grafton,	Commons Club.
Booth, Alfred,[1]	Middletown, N. Y.,	Baker Place.
Boyce, Harold Prescott,[1]	Haverhill,	7 Nutting Avenue.
Buckman, Lewis Taylor,	Wilkes-Barre, Pa.,	Theta Chi.

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[1] Work incomplete.

Buttrick, David Herbert,	Arlington,	Phi Sigma Kappa.
Carruth, Glenn Howard,[1]	Orange,	Physics Building.
Chamberlin, Frank Shirley,	Framingham,	Commons Club.
Clough, Charles Henry,[1]	Dedham,	Beta Kappa Phi.
Cross, Walter Irving,[1]	Hingham Center,	53 Lincoln Avenue.
Curtin, Charles Warren,[1]	Newton,	Lambda Chi Alpha.
Davis, Monsell Henry,	Orange, N. J.,	120 Pleasant Street.
Day, James Harold,[1]	Hatfield,	8 North College.
Dempsey, Paul Wheeler,	Dorchester,	Lambda Chi Alpha.
Dickey, Harold Gammell,	Dorchester,	6 South College.
Dizer, John Thomas,	East Weymouth,	East Experiment Station.
Duffill, Edward Stanley,	Melrose Highlands,	8 Allen Street.
Dunham, Henry Gurney,[1]	West Bridgewater,	Beta Kappa Phi.
Edwards, Francis Gill,[1]	Beverly,	Phi Sigma Kappa.
Elliot, Ralph William,	Chartley,	Flint Laboratory.
Everbeck, George Charles,[1]	Boston,	87 Pleasant Street.
Fearing, Ralph Watson,	Dorchester,	Commons Club.
Fisher, George Basil,[1]	Millbury,	Theta Chi.
Flagg, Wayne McCrillis,[1]	Mittineague,	Beta Kappa Phi.
Flint, Oliver Simeon,	Lowell,	120 Pleasant Street.
Goldstein, Maurice,[1]	Lynn,	58 Pleasant Street.
Graham, Leland Jenkins,[1]	Amherst,	Lincoln Avenue.
Grayson, Emory Ellsworth,	Milford,	Alpha Sigma Phi.
Gurshin, Carl Alfred,	Lynn,	35 North Prospect Street.
Hagelstein, Charles Henry,[1]	Dorchester,	4 North College.
Hallett, Charles Hiram,[1]	Mansfield,	Theta Chi.
Harlow, Frank Edward,	Malden,	77 Pleasant Street.
Harlow, Paul Goodhue,	Malden,	Phi Sigma Kappa.
Henderson, Elliott,	Boston,	7 South College.
Henninger, Roswell Woodward,	Williamsport, Pa.,	3 McClellan Street.
Higginbotham, Harry,[1]	Taunton,	North College.
Hill, Edmund Baldwin,[1]	Rutherford, N. J.,	Alpha Sigma Phi.
Holden, Richard Lynde,	Haverhill,	Lambda Chi Alpha.
Holder, Ralph Clifton,	South Braintree,	17 Kellogg Avenue.
Hubbell, Franklin Homer,	Westport, Conn.,	M. A. C. Farm House.
Hyde, Stanley Winship,[1]	Malden,	66 Pleasant Street.
Irving, William Raymond,	Taunton,	North College.
Jackson, Richmond Merrill,[1]	Georgetown,	Commons Club.
Kelsey, Edmund Dean,[1]	Amherst,	Commons Club.
Kelsey, Lincoln David,	West Hartford, Conn.,	Beta Kappa Phi.
Kinsman, Alfred Oberlin, Jr.,[1]	Merrimac,	Lambda Chi Alpha.
Larson, Frederick Christian,[1]	Everett,	4 North College.
Latham, Paul Walker,	Norwichtown, Conn.,	Kappa Sigma.
Lawrence, Milford Robinson,	Falmouth,	Kappa Sigma.
Light, Brooks,[1]	Milton,	15 North College.
Livermore, William Tingley,	Lawrence,	83 Pleasant Street.
Loring, Albert Briggs,	Nantasket Beach,	Stockbridge Hall.
Lydiard, Harry Crowther,[1]	Hartford, Conn.,	3 Nutting Avenue.
Mack, Walter Adams,	Springfield,	8 North College.
MacLeod, Daniel Johnston,[1]	Wakefield,	Hillside Avenue.
Marchant, Horace Greenough,[1]	Cambridge,	5 Fearing Street.
Mather, Fred,[1]	Amherst,	Veterinary Laboratory.
Mayo, Frank Willard,[1]	Houlton, Me.,	Phi Sigma Kappa.
Mayo, William Irving, Jr.,	Framingham Center,	M. A. C. Farm House.
Merrill, Dana Otis,[1]	East Pepperell,	Commons Club.
Moorhouse, Newell,	Worcester,	5 South College.
Nash, Herman Beaman,	Amherst,	Amherst, R. F. D. No. 1.
Nelson, John Brockway,[1]	Newburyport,	Baker Place.
Noyes, Samuel Verne,	Georgetown,	Beta Kappa Phi.
Pierce, Harold Barnard,	Kansas City, Mo.,	80 Pleasant Street.
Pike, Chester Arthur,[1]	Smith's,	Mathematics Building.
Pratt, Harold Arthur,	Shrewsbury,	Lambda Chi Alpha.

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[1] Work incomplete.

Quimby, Charles Frederick,	Cape Neddick, Me.,	83 Pleasant Street.
Randall, Earle MacNeill,	Winchester,	Lambda Chi Alpha.
Richardson, Lewis Elmer,	Rockville,	Lambda Chi Alpha.
Rodger, Raymond Miller,	Everett,	Beta Kappa Phi.
Rogers, Roland Winsor,	Braintree,	25 Lincoln Avenue.
Rorstrom, Hans Alfred,	Boston,	M. A. C. Farm House.
Ross, Louis Warren,[1]	Arlington,	Phi Sigma Kappa.
Saidel, Harry Samuel,[1]	Worcester,	3 Nutting Avenue.
Sargent, George Leonard,[1]	Merrimac,	17 Kellogg Avenue.
Saunders, William Putnam,	Lawrence,	116 Pleasant Street.
Sauter, John Martin,[1]	Turners Falls,	60 Pleasant Street.
Saville, William, Jr.,	Waban,	20 South College.
Schaefer, Leonard Charles,[1]	Holyoke,	Entomology Building.
Schwab, Andrew Nathan,[1]	Yalesville, Conn.,	Plant House.
Shumway, Paul Edward,[1]	Greenfield,	60 Pleasant Street.
Sims, James Stanley,[1]	Melrose,	Phi Sigma Kappa.
Smith, Herbert Dwight,	Northampton,	60 Pleasant Street.
Smith, Richard Woodworth,	Pittsfield,	Kappa Sigma.
Spaulding, Almon Whitney,	Dorchester,	16 South College.
Squires, Paul Revere,[1]	Belchertown,	Belchertown.
Stearns, Carlton McIntyre,[1]	Melrose,	120 Pleasant Street.
Stiles, Albert Ralph,[1]	Arlington Heights,	8 South College.
Stowell, Harold Thurber,[1]	Amherst,	193 South Pleasant Street.
Thayer, William Wallace,	Winter Hill,	Lambda Chi Alpha.
Tuthill, Samuel Fuller,	Mattapoisett,	M. A. C. Farm House.
Upson, Everett Langdon,[1]	New Britain, Conn.,	87 Pleasant Street.
Walbridge, Henry Blood,	Bennington, Vt.,	M. A. C. Farm House.
Warner, Merrill Pomeroy,	Sunderland,	5 South College.
Warren, Harold Manson,[1]	Melrose,	13 North College.
Warren, James Joseph,	North Brookfield,	Commons Club.
Webster, Frank Cedric,	Harvard,	Mathematics Building.
Westman, Robert Clayton,	Roslindale,	Baker Place.
Whitcomb, Warren Draper,[1]	Waltham,	Theta Chi.
Whitney, Joseph Fradley,[1]	Brooklyn, N. Y.,	Kappa Sigma.
Wilber, Charles Raymond,	Walpole,	French Hall.
Wilcox, Timothy Palmer,	Andover,	Alpha Sigma Phi.
Williams, Arthur Franklin,[1]	Sunderland,	6 South College.
Williams, Herbert Clifton,[1]	South Hadley Falls,	Whitney Street.

Sophomore Class.

Additon, Elizabeth Emery,	Newton Center,	Draper Hall.
Allen, Amos Lawrence,	Dalton,	87 Pleasant Street.
Allen, Leland Christy,[1]	Holyoke,	120 Pleasant Street.
Allen, Ralph Emerson,	Everett,	Commons Club.
Babbitt, Frank Madison,	Fairhaven,	M. A. C. Farm House.
Bainbridge, Frank Benedict,	Paterson, N. J.,	6 South College.
Baker, Foster Kenneth,	Fairhaven,	Entomology Building.
Baker, Henry Raymond,[1]	Amherst,	West Street.
Barton, George Wendell,	North Sudbury,	36 North Prospect Street.
Bent, Winthrop Herbert,[1]	Watertown,	87 Pleasant Street.
Binks, Frank Joseph,	Maynard,	Beta Kappa Phi.
Boaz, William Henry,[1]	Covesville, Va.,	Phi Sigma Kappa.
Boyd, Robert Lucius,[1]	Lynn,	3 Nutting Avenue.
Brigham, Sylvia Bowen,	Newtonville,	Draper Hall.
Bruce, Walter Griffith,	Springfield,	21 Fearing Street.
Buchanan, Walter Gray,[1]	Chicopee,	97 Pleasant Street.
Buck, Rollin Hugh,	Worcester,	Beta Kappa Phi.
Burtch, Chester Swan,	New Bedford,	Theta Chi.
Calderwood, Herbert Hale,[1]	Rockport, Me.,	Kappa Sigma.
Canlett, Franklin Harwood,	Bedford,	36 North Prospect Street.
Capen, Howard Boyden,[1]	Canton,	Lambda Chi Alpha.

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[1] Work incomplete.

Carlson, Fred Albert,	Pittsfield,	84 Pleasant Street.
Carter, Thomas Edward,	West Andover,	Lambda Chi Alpha.
Chamberlain, Sumner Fiske,[1]	Holden,	Commons Club.
Chambers, Roger James,[1]	Dorchester,	Alpha Sigma Phi.
Chapman, John Alden,	Salem,	10 Nutting Avenue.
Clapp, Roger Francis,	Salem,	79 Pleasant Street.
Clark, Stewart Sandy,[1]	Holyoke,	120 Pleasant Street.
Davis, Dwight Shaw,	Derry, N. H.,	66 Pleasant Street.
Dillon, Thomas Stevenson,	West Warren,	Aggie Inn.
Dowd, William Lawrence,[1]	North Amherst,	North Amherst.
Duncan, George James,[1]	Arlington,	3 Nutting Avenue.
Dunn, Arthur Paul,[1]	Malden,	29 McClellan Street.
Durfee, Norman Owen,[1]	Fall River,	Alpha Sigma Phi.
Edes, David Oliver Nourse,[1]	Bolton,	Lambda Chi Alpha.
Ellis, Ralph Chick,[1]	West Newton,	3 Nutting Avenue.
Emmerich, Louis Philip,[1]	Paterson, N. J.,	9 South College.
Erickson, George Edwin,	Brockton,	Lincoln Avenue.
Faber, Edward Stuart,[1]	Plainfield, N. J.,	Theta Chi.
Faneuf, Leo Joseph,[1]	West Warren,	Birch Lawn.
Farrar, Delwin Bruce,[1]	Amherst,	1 Dana Street.
Fellows, Harold Carter,[1]	Peabody,	Commons Club.
Ferriss, Samuel Boynton,	New Milford, Conn.,	Beta Kappa Phi.
Foley, William Albert,	Palmer,	35 North Prospect Street.
Foster, Hamilton Knight,[1]	New Rochelle, N. Y.,	24 Beston Street.
Foster, Roy Wentworth,	Lynn,	6 Nutting Avenue.
Francis, Donald Smith,[1]	Athol,	Beta Kappa Phi.
Fraser, Charles Allen,[1]	Plymouth,	Baker Place.
Frellick, Arthur Lester,	Everett,	13 Phillips Street.
Fuller, Camille Baldwin,	West Quincy,	Commons Club.
Garvey, Mary Ellen Monica,	Amherst,	27 South Prospect Street.
Gasser, Thomas Jefferson,	Uxbridge,	Lincoln Avenue.
Gifford, Flavel Mayhew,	West Tisbury,	Commons Club.
Gillette, Nathan Warner,	Revere,	5 South College.
Goodridge, George Lucien,[1]	Melrose,	Lambda Chi Alpha.
Goodwin, William Irving,[1]	Haverhill,	Lambda Chi Alpha.
Gordon, Frederick George,	Plymouth,	North Pleasant Street.
Gray, Milton Berford,[1]	Woods Hole,	13 Phillips Street.
Grayson, Forrest,	Milford,	Lincoln Avenue.
Haines, Foster Kingsley,	Peabody,	120 Pleasant Street.
Hance, Forrest Sansbury,[1]	Paterson, N. J.,	3 Nutting Avenue.
Harris, Warren Timothy,[1]	Millbury,	60 Pleasant Street.
Harwood, Ralph Wallace,	Barre,	Phi Sigma Kappa.
Hawley, Robert Dorman,	Springfield,	Phi Sigma Kappa.
Heffron, Paul John,[1]	Sherborn,	Birch Lawn.
Higgins, Leo Clement,	Amesbury,	Poultry Plant.
Holmes, George Frederick,	Ipswich,	30 North Prospect Street.
Holmes, Robert Palmer,[1]	Wakefield,	Kappa Sigma.
Howard, Arthur Merchant,	Pittsfield,	84 Pleasant Street.
Howe, Albert Edward,[1]	Needham,	Lincoln Avenue.
Howe, George Cole,	Worcester,	Lincoln Avenue.
Howes, Donald Francis,	Ashfield,	Birch Lawn.
Hunnewell, Paul Fiske,[1]	Winthrop,	13 Phillips Street.
Huntoon, Douglas Henderson,	Norwood,	13 Phillips Street.
Hurlburt, Ralph Walter,	Ashley Falls,	94 Pleasant Street.
Ingalls, Irving Weaver,[1]	Brooklyn, N. Y.,	Beta Kappa Phi.
Jackson, Charles Henry,[1]	Lexington,	Theta Chi.
Jepsky, Abraham,	East Boston,	North Amherst.
Johnson, Birger Lars,	Dorchester,	29 McClellan Street.
Johnson, Sidney Clarence,[1]	Gloucester,	13 Phillips Street.
Jones, Forrest Dean,	Worcester,	116 Pleasant Street.
Jones, Harold Ellis,	New Canaan, Conn.,	Care of E. F. Gaskill.
Kennedy, Carl Francis,	Milford,	23 Amity Street.

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[1] Work incomplete.

Lanphear, Marshall Olin,	Windsor, Conn.,	Kappa Sigma.
Lasker, David,[1]	Hyde Park,	31 Pleasant Street.
Lawrence, Lewis Henry,[1]	Falmouth,	83 Pleasant Street.
Lawton, Ralph Wilber,	Fall River,	75 Pleasant Street.
Levine, Darwin Solomon,[1]	Sherborn,	31 Pleasant Street.
Lipshires, David Mathew,	Roxbury,	Flint Laboratory.
Loring, William Rupert,	Great Barrington,	Physics Building.
Lyons, Louis Martin,	Rockland,	29 North Prospect Street.
Maginnis, John Joseph,[1]	Lawrence,	35 North Prospect Street.
Mallorey, Alfred Sidney,	Lynn,	15 Hallock Street.
Marshall, Max Skidmore,	Amherst,	44 Sunset Avenue.
McKee, William Henry,	Chelsea,	Theta Chi.
McNamara, Michael Joseph,[1]	Stoughton,	Stockbridge Hall.
McNaught, Warren Henry,[1]	Plymouth,	Baker Place.
McRae, Herbert Ranklin,[1]	Malden,	4 Nutting Avenue.
Messenger, Kenneth Leroy,	Winsted, Conn.,	Kappa Sigma.
Millard, Harold Baldwin,	Great Barrington,	Fitts House.
Minor, John Bacon, Jr.,[1]	New Britain, Conn.,	Kappa Sigma.
Mitchell, Edward Nahum,[1]	Medford,	Phi Sigma Kappa.
Mitchell, Theodore Bertis,	Needham,	Lambda Chi Alpha.
Mower, Carl Taft,[1]	Montpelier, Vt.,	Kappa Sigma.
Moynihan, Patrick Joseph,[1]	Holyoke,	Columbia Café.
Murrin, James Patrick,[1]	Dorchester,	Baker Place.
Newton, Edward Buckland,[1]	Holyoke,	120 Pleasant Street.
Newton, Gaylord Arthur,	Durham, Conn.,	3 Fearing Street.
Norcross, Gardner Clyde,	Brimfield,	58 Pleasant Street.
Odams, Lester Nichols,[1]	Salem,	83 Pleasant Street.
Oertel, August Leonard,[1]	South Hadley Falls,	Pleasant Street.
O'Heron, Francis James,[1]	East Milton,.	5 Fearing Street.
O'Keeffe, John Philip,[1]	Millers Falls,	60 Pleasant Street.
O'Neill, Oliver Maurice,	Dorchester,	29 McClellan Street.
Patch, Lawrence Henry,	Wenham,	Plant House.
Petit, Arthur Victor,	Amherst,	31 East Pleasant Street.
Phipps, Clarence Ritchie,	Dorchester,	Theta Chi.
Popp, Edward Williams,	Albany, N. Y.,	3 McClellan Street.
Powell, James Congdon,	Newport, R. I.,	20 South College.
Pratt, Oliver Goodell,	Salem,	Kappa Sigma.
Preble, John Nelson,	Jamaica Plain,	116 Pleasant Street.
Raymond, Clinton Rufus,	Beverly,	Lambda Chi Alpha.
Reumann, Theodore Henry,	New Bedford,	87 Pleasant Street.
Richardson, Stephen Morse,	Montague,	9 South College.
Ritter, Ernest,[1]	New Britain, Conn.,	Theta Chi.
Robbins, Waldo Whiting,[1]	South Hingham,	53 Lincoln Avenue.
Roberts, Oliver Cousens,	Roxbury,	Theta Chi.
Robinson, William Herbert,	Lynn,	87 Pleasant Street.
Rosequist, Birger Reignold,[1]	Brockton,	18 Nutting Avenue.
Russell, Howard Leigh,	Worcester,	116 Pleasant Street.
Rutter, Walter Frederick,	Lawrence,	17 Fearing Street.
St. George, Raymond Alexander,[1]	Lynn,	15 Hallock Street.
Sampson, Fred Bucknam,[1]	Fall River,	60 Pleasant Street.
Sanborn, Deane Waldron,	Nantucket,	North Pleasant Street.
Sawyer, Wesley Stevens,[1]	Jamaica Plain,	Beta Kappa Phi.
Sawyer, William George,	Berlin,	7 South College.
Schlough, George Homer,[1]	Waltham,	6 Nutting Avenue.
Schwartz, Louis,[1]	Melrose,	West Experiment Station.
Seavey, Arthur Jones,[1]	New Braintree,	Theta Chi.
Sedgwick, Alfred,[1]	Fall River,	Alpha Sigma Phi.
Smith, Carleton Tower,	West Newton,	116 Pleasant Street.
Smith, Sidney Sumner,	Roslindale,	116 Pleasant Street.
Spaulding, Lewis Winans,[1]	South Hingham,	8 South College.
Spencer, Arthur Winthrop,[1]	Danvers,	North College.
Stackpole, Frank Charles,[1]	Somerville,	Lambda Chi Alpha.

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[1] Work incomplete.

Stowe, Raymond Timothy,	Scitico, Conn.,	15 Hallock Street.
Stowers, Addison Clifford,	Dorchester,	15 Phillips Street.
Strong, William Perkins,[1]	South Hadley Falls,	Pine Street, North Amherst.
Sullivan, Harold Leo,	Lawrence,	7 North College.
Sutherland, Ralph,	Cambridge,	Alpha Sigma Phi.
Thompson, Wells Nash,[1]	Adams,	Alpha Sigma Phi.
Thorpe, Richard Warren,	West Medford,	15 Beston Street.
Tilton, Arthur Dana,[1]	Wellesley,	Phi Sigma Kappa.
vanAlstyne, Lewis Morrell,[1]	Kinderhook, N. Y.,	Baker Place.
Vickers, John,[1]	Amherst,	Beta Kappa Phi.
Walker, George Jones,[2]	Lexington,	– –
Weeks, Roger Wolcott,	Hyde Park,	Kappa Sigma.
Wilbur, Laurence Weston,	South Middleborough,	Beta Kappa Phi.
Willoughby, Raymond Royce,	New Britain, Conn.,	Care of E. F. Gaskill.
Wooding, Paul Bennett,[1]	Yalesville, Conn.,	M. A. C. Plant House.
Woodworth, Brooks,	Lowell,	Lincoln Avenue.
Worthley, Harlan Noyes,	Greenwood,	Flint Laboratory.
Yesair, John,[1]	Byfield,	Kappa Sigma.

FRESHMAN CLASS.

Abrams, Jacob,[1]	East Boston,	North Amherst.
Alden, Dean Watson,[1]	Proctor, Vt.,	North Amherst.
Anderson, George,[1]	Somerville,	15 Beston Street.
Andrews, Milton Earle,	Hammonton, N. J.,	30 North Prospect Street.
Bailey, William,[1]	Williamstown,	North Amherst.
Baker, William Alphonso,[1]	Melrose,	66 Pleasant Street.
Baker, William Herbert, Jr.,	Chesterfield,	5 Nutting Avenue.
Bartlett, Samuel Colcord, Jr.,	Colerain,	81 Pleasant Street.
Batchelder, Stewart Putnam,	North Reading,	66 Pleasant Street.
Bath, Richard George,	West Springfield,	5 McClellan Street.
Batista, Victor,	Havana, Cuba,	79 Pleasant Street.
Beadle, Herbert Ocumpaugh,	Lima, N. Y.,	18 Nutting Avenue.
Bigelow, George Samuel,[1]	Millville, N. J.,	Lincoln Avenue.
Blanchard, Carlton Douglas,	Uxbridge,	9 Phillips Street.
Blanchard, George Kinson,	Abington,	Baker Place.
Boland, Kells Shepard,	South Boston,	9 Fearing Street.
Bond, Herbert Richard,	Dover,	Lincoln Avenue.
Bowen, Arthur Newton,[1]	Wollaston,	15 Phillips Street.
Bowen, Maurice Stetson,[1]	Lakeville,	81 Pleasant Street.
Bower, Richard,[1]	Braintree,	Baker Place.
Boyce, Alan Freeman,[1]	Melrose,	Baker Place.
Boynton, Raymond Woods,[1]	Framingham,	120 Pleasant Street.
Brigham, Paul Tracy,	Leominster,	77 Pleasant Street.
Brown, Ralph Hall,	Ayer,	17 Phillips Street.
Buffum, Eliot Mansfield,	Waban,	77 Pleasant Street.
Burt, Henry John,	West Somerville,	75 Pleasant Street.
Burton, Lee Williams,	Plainville,	58 Pleasant Street.
Callanan, John Edward,	Dorchester,	60 Pleasant Street.
Callanan, Vincent DePaul,	Malden,	4 Chestnut Street.
Campbell, Donald Lincoln,[1]	South Deerfield,	66 Pleasant Street.
Campbell, George Murray,[1]	Baltimore, Md.,	Mount Pleasant.
Carley, Harry Gray,[1]	West Newton,	Lincoln Avenue.
Carpenter, Hall Bryant,[1]	Somerville,	14 Nutting Avenue.
Carroll, Olive Evangeline,[1]	Dorchester,	Draper Hall.
Cassidy, Morton Harding,	East Boston,	3 McClellan Street.
Chadbourne, Joseph Alfred,	Great Barrington,	87 Pleasant Street.
Chandler, Arthur Lincoln,	Leominster,	77 Pleasant Street.
Chapin, Frederic Charles,	Greenfield,	15 Beston Street.
Chase, Chester Ingalls,[1]	Melrose,	17 Phillips Street.
Chase, Malcolm Willis,	Amesbury,	4 Chestnut Street.
Chisholm, Robert Dudley,	Melrose Highlands,	66 Pleasant Street.

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[1] Work incomplete.

[2] Entered in February, 1915; left in June, 1915.

Clapp, Agustus Warren,	East Braintree,	Baker Place.
Clark, Francis Marsh,	Oxford,	1 Allen Street.
Coderre, Ernest Laurier,	Southbridge,	35 North Prospect Street.
Coe, Elmore Holloway,[1]	Rockfall, Conn.,	16 Nutting Avenue.
Cole, Frederick Eugene, Jr.,	South Portland, Me.,	North Amherst.
Collins, Robert Burleigh,	Rockland,	116 Pleasant Street.
Cone, Willis Refine,[1]	Mittineague,	5 McClellan Street.
Cooley, Edwin Prince,	Sunderland,	Sunderland Road.
Copeland, Raymond Norman,[1]	Hyde Park,	44 Pleasant Street.
Cosby, Alfred Francis,	Westfield,	15 Amity Street.
Crawford, Aaron Ennis,	Greenfield,	60 Pleasant Street.
Crimmin, Royce Brainerd,	Haverhill,	7 Nutting Avenue.
Crowe, Charles,	Norwich, Conn.,	Baker Place.
Davies, James Pillsbury,[1]	Cambridge,	6 Phillips Street.
Day, Elston Almond,	Northbridge,	58 Pleasant Street.
Day, Harold Ralph,[1]	Hopedale,	Baker Place.
Desmond, Thomas Whitty,[1]	Randolph,	Baker Place.
Dickinson, Victor Abel,[1]	Amherst,	Mount Pleasant.
Donigan, Henry Joseph,	Marion,	North Amherst.
Douglas, Effie Pearl,[1]	Amherst,	High Street.
Dunbar, Charles Oliver,	Westfield,	7 Allen Street.
Dunn, Leslie Burnham,[1]	Melrose Highlands,	5 Nutting Avenue.
Dwyer, James Edward,	South Deerfield,	17 Phillips Street.
Edmonds, Reginald Whitney,	Roslindale,	37 North Prospect Street.
Eilertsen, Arthur Oliver,[1]	Roslindale,	116 Pleasant Street.
Erhard, Bena Gertrude,[1]	East Milton,	Draper Hall.
Erickson, Gunnar Emmanuel,	Lynn,	North Amherst.
Evans, Myrton Files,	West Somerville,	14 Nutting Avenue.
Faneuf, Ambrose Clement,	West Warren,	Birch Lawn.
Farrington, Robert Pierce,[1]	Nantucket,	Birch Lawn.
Faxon, Paul,	West Newton,	77 Pleasant Street.
Fellows, Katharine Adelheid,	Northampton,	21 Amity Street.
Field, John Bacon,[1]	Sharon,	4 Chestnut Street.
Field, Wilbert Daniel,[1]	Somerville,	6 Nutting Avenue.
Finkelstein, Hyman,	East Boston,	– –
Fiske, Eustace Bridge,	Somerville,	75 Pleasant Street.
Fogg, Verne Allen,[1]	Topsfield,	4 Chestnut Street.
French, Willard Kyte,	Worcester,	6 Phillips Street.
Garde, Earl Augustus,	Lynn,	Pease Avenue.
Gay, Laurence Washburn,	Groton,	116 Pleasant Street.
Gilligan, Gerald Mathew,[1]	West Warren,	12 South Prospect Street.
Glavin, William Francis,	Wenham,	6 Phillips Street.
Goff, Howard Mason,	Everett,	120 Pleasant Street.
Graves, Walter Decker,[1]	Brookline,	Baker Place.
Gray, Harold Frederick,	Townsend Harbor,	5 Nutting Avenue.
Green, Lynn,	Schenevus, N. Y.,	75 Pleasant Street.
Grout, Nathan,[1]	Sherborn,	60 Pleasant Street.
Guba, Emil Frederick,[1]	New Bedford,	12 Cottage Street.
Gurshin, Melvin William,	Lynn,	35 North Prospect Street.
Hall, Frank Edwin,[1]	Rockland,	Aggie Inn.
Hamilton, Howard Milton,[1]	Winchester,	Cottage Street.
Harding, George Warren,[1]	Somerville,	14 Nutting Avenue.
Harris, Ethel Lovett,[1]	Beverly,	Draper Hall.
Hartwell, Richard Raymond,	Springfield,	Baker Place.
Haslam, Emerson Francis,	Hyde Park,	3 Nutting Avenue.
Hastings, Louis Pease,	Springfield,	Baker Place.
Hathaway, Wilfred Adelbert,	Berkley,	44 Triangle Street.
Hayes, John Anthony,	Milford,	Mount Pleasant.
Hession, William Joseph,	Somerville,	14 Nutting Avenue.
Hodgson, Benjamin Earl,	Methuen,	22 Amity Street.
Holmgren, Richard Sigfrid,	East Lynn,	15 Hallock Street.
Hopkins, George Randolph Lawrence,[1]	Orleans,	60 Pleasant Street.

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[1] Work incomplete.

Howe, Ralph Thomas,	Melrose Highlands,	5 Nutting Avenue.
Howland, George Herbert,[1]	Melrose Highlands,	83 Pleasant Street.
Jewell, Charles Henry,	Merrimac,	17 Kellogg Avenue.
Johnson, Lawrence Wilhelm,	Avon,	12 Cottage Street.
Jones, Edson Temple,[1]	Roslindale,	42 McClellan Street.
Jordan, Raymond Douglas,[1]	Springfield,	21 Fearing Street.
Kelley, Kenneth Gordon,	Lynn,	– –
Kennedy, Alan Giles,[1]	Milford,	21 Amity Street.
King, William Cutting,[1]	Suffield, Conn.,	5 Sunset Avenue.
Knight, Frank Edward,	Brimfield,	58 Pleasant Street.
Kolpack, Harry William,	East Boston,	North Amherst.
Leavitt, John Woodbury,	Dorchester,	18 Nutting Avenue.
Liebman, Anna,[1]	Dorchester,	38 Cottage Street.
Lochiades, Charilaos George,[1]	Springfield,	67 Pleasant Street.
Logan, Milan Alexander,[1]	Brockton,	North Amherst.
Macdonald, Harold Ray,	Buzzards Bay,	6 Phillips Street.
Mahon, John Joseph,	New Canaan, Conn.,	Baker Place.
Mansell, Elton Jessup,	Cambridge,	15 Beston Street.
Martin, Chester Walter,[1]	Orange,	Baker Place.
Mattoon, Charles Gordon,	Pittsfield,	120 Pleasant Street.
McCarthy, Arthur Martin,[1]	Monson,	East Pleasant Street.
McGivern, Eugene Augustine,	Lynn,	44 Triangle Street.
Montgomery, Arthur Bird,	Dedham,	44 Pleasant Street.
Montgomery, Forest Kimball,	East Orange, N. J.,	Baker Place.
Moor, Erwin Charles,	Lynn,	7 Allen Street.
Moore, John Raymond,	Tolland,	Birch Lawn.
Morgan, Earl Amos,	Amherst,	2 Allen Street.
Morse, Louis Edgar, Jr.,	North Attleborough,	101 Pleasant Street.
Morton, Elmer Joshua,[1]	Waltham,	4 Chestnut Street.
Moskowitz, Maurice,	Dorchester,	31 Pleasant Street.
Munroe, Raymond Franklin,	Fall River,	77 Pleasant Street.
Newbold, Douglas Tracy,	Northampton,	Lincoln Avenue.
Newton, Raymond Lovejoy,[1]	Malden,	15 Fearing Street.
O'Hara, Joseph Ernest,[1]	Worcester,	6 Phillips Street.
Parke, Robert Warren,	Winchendon,	7 Allen Street.
Parkhurst, Raymond Thurston,	Fitchburg,	53 Lincoln Avenue.
Parsons, Edward Field,	North Amherst,	North Amherst.
Peck, George Newberry,[1]	Wilson, Conn.,	75 Pleasant Street.
Peck, Roger Eugene,	Shelburne,	5 McClellan Street.
Peirson, Henry Byron,	Haverhill,	7 Nutting Avenue.
Perry, Errol Clinton,[1]	Acushnet,	15 Hallock Street.
Peterson, Leroy Duane,	Greenfield,	44 Triangle Street.
Phemister, Robert Grey,	Providence, R. I.,	15 Phillips Street.
Pierpont, Frederick Trowbridge,	Chester, Pa.,	7 Nutting Avenue.
Platt, William Sherman,	Leominster,	7 Nutting Avenue.
Pond, Allan Leon,	Holliston,	15 Phillips Street.
Poole, Harold Walter,	Hudson,	96 Pleasant Street.
Prée, Karl Julius,	Brookline,	81 Pleasant Street.
Pulley, Marion Gertrude,	Melrose,	2 Allen Street.
Quimby, Arthur Edmund,	Somerville,	36 North Prospect Street.
Rea, Julian Stuart,[1]	Weymouth,	Lincoln Avenue.
Readio, Roger Frank,	Florence,	120 Pleasant Street.
Rice, Harold Miller,	Kensington, Conn.,	3 McClellan Street.
Roberts, Mark Anthony,[1]	Dorchester,	17 Phillips Street.
Ross, Donald,	Arlington,	15 Beston Street.
Rowe, Clifford Alton,[1]	East Orange, N. J.,	81 Pleasant Street.
Sampson, George Austin,[1]	Allston,	15 Phillips Street.
Sargent, Walter Harriman,	Malden,	4 Chestnut Street.
Schenkelberger, Frederic,[1]	Quincy,	Aggie Inn.
Seavey, Paul Stanley,[1]	Cambridge,	17 Fearing Street.
Sexton, Ernest Francis,	Darien, Conn.,	Baker Place.
Sheldon, Howard Rhoades,	New Marlborough,	4 Chestnut Street.

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[1] Work incomplete.

Sibley, Helen Araminta,	Longmeadow,	Draper Hall.
Skinner, Everett Hamilton,[1]	West Upton,	Baker Place.
Smallwood, John Henry,	Paterson, N. J.,	3 Nutting Avenue.
Smith, Jonathan Harold,	Roslindale,	116 Pleasant Street.
Smith, Wendell Frederick,[1]	Troy, N. Y.,	75 Pleasant Street.
Snow, Palmer Prince,	Barnstable,	North Amherst.
Spaulding, Harold Edwin,[1]	Milford,	Baker Place.
Sproul, Walton Dyer,	Norwell,	29 North Prospect Street.
Stafford, Irving Boynton,	Fall River,	75 Pleasant Street.
Stearns, Horace David,	Waltham,	3 McClellan Street.
Stevens, Chester Dillingham,	Reading,	66 Pleasant Street.
Stockbridge, John Sylvester,	Atlanta, Ga.,	Farview Way.
Stockwell, Erwin Sidney, Jr.,	Sharon,	81 Pleasant Street.
Strack, Edward,	Framingham,	Clark Hall.
Stuart, Vincent Cyril,	Newton,	Aggie Inn.
Sweeney, William Joseph,[1]	Dorchester,	Hillside Avenue.
Swift, Hubbard,	West Falmouth,	10 South College.
Taylor, Edmund Billings,[1]	Wollaston,	81 Pleasant Street.
Thayer, Julian Bailey,	Durham Center, Conn.,	36 North Prospect Street.
Thayer, Weston Cushing,	Hingham,	53 Lincoln Avenue.
Thomas, Daniel Joseph,[1]	Turners Falls,	36 North Prospect Street.
Thomas, Frank DesAutel,[1]	Milford,	Mount Pleasant.
Tietz, Harrison,	Richmond Hill, N. Y.,	Brooks Farm.
Tirrell, Loring Vinson,[1]	South Weymouth,	16 Nutting Avenue.
Waite, Richard Austin,	Middlefield,	17 Phillips Street.
Wells, Marion Nichols,	Springfield,	Draper Hall.
Wheeler, Russell Hubbell,	Newtown, Conn.,	M. A. C. Farm House.
White, Edward Asa,	Providence, R. I.,	North Pleasant Street.
White, George Lansford,[1]	Great Barrington,	87 Pleasant Street.
Whittle, Clarence Parker, Jr.,	Weymouth,	16 Nutting Avenue.
Wilder, Charles Henry,	Springfield,	21 Fearing Street.
Williams, Allan Carruth,	Rockland,	29 North Prospect Street.
Williams, Kenneth Sanderson,	Sunderland,	17 Phillips Street.
Willis, Howard Curtis,[1]	Amherst,	13 Cottage Street.
Window, James Joseph,	Lynn,	7 Allen Street.
Window, Thomas,[1]	Lynn,	7 Allen Street.
Wing, Arland Junius,	Danvers,	12 Cottage Street.
Wiswell, Ray Herbert,	Northampton,	66 Pleasant Street.
Wood, Ernest Perry,	Mendon,	7 Phillips Street.
Wood, Oliver Wiswell,	Arlington,	81 Pleasant Street.
Woodard, Chester Smith,	Leverett,	Leverett.
Woodbury, Ray Willard,	Newburyport,	Cottage Street.
Woods, Frank Archibald,	Groton,	83 Pleasant Street.
Woodside, Wilfred Livingstone,[1]	Auburndale,	4 Chestnut Street.
Wright, John Lindsey,[1]	Putnam, Conn.,	Kappa Sigma.
Wright, Livingstone,[1]	Quincy,	4 Chestnut Street.

UNCLASSIFIED STUDENTS.

Allen, Arthur Frederic,	Cambridge,	Prospect House.
Avery, Humphrey Roger,	Patchogue, N. Y.,	77 Pleasant Street.
Berry, Fred Mitchell,	Lynnfield Center,	120 Pleasant Street.
Bridgman, Ralph Scofield,	Westhampton,	60 Pleasant Street.
Campbell, John Collins,	Gardner,	Baker Place.
Churchill, Chester Albert,	Brockton,	18 Nutting Avenue.
Clancy, Henry Gregory,	Natick,	Baker Place.
Crane, Arthur Francis,	North Hanover,	24 Beston Street.
Cross, Robert Earle,	Agawam,	21 Fearing Street.
Derby, Llewellyn Light,[1]	Hudson,	Baker Place.
Emerson, Caroline Dwight,	Amherst,	21 Northampton Road.
Gamage, Carl Everett,	Lynn,	– –
Grundler, Adolph Joseph,	Lowell,	120 Pleasant Street.

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[1] Work incomplete.

Gustafson, Helmar Gustaf,	Springfield,	18 Hallock Street.
Hill, Donald Russell,	Arlington,	29 McClellan Street.
Jones, Percival,	Cambridge,	Mount Pleasant.
Kidder, Addison Richard,	Wardsboro, Vt.,	3 McClure Street.
Leary, Frank Dennis,	Brockton,	12 Cottage Street.
McLean, George Robert,[1]	Northampton,	60 Washington Avenue, Northampton.
McManus, Mark Augustine,	Lawrence,	101 Pleasant Street.
Morse, Louis Lincoln,	Dorchester,	7 Allen Street.
Norris, Harold Allison,	Amherst,	North Amherst.
Phillips, Everett Daniel,	Brookline,	101 Pleasant Street.
Spaulding, Lyford Pingree,	Lexington,	77 Pleasant Street.
Stebbins, Blanchard,	Newton,	– –

SUMMARY BY CLASSES.

Graduate students,	52
Senior class,	108
Junior class,	110
Sophomore class,	162
Freshman class,	211
Unclassified students,	25
Total registration,	668

GEOGRAPHICAL SUMMARY.

Massachusetts,	564
Connecticut,	30
New York,	21
New Jersey,	14
Pennsylvania,	6
Maine,	5
Vermont,	5
Rhode Island,	4
New Hampshire,	3
Canada,	2
California,	1
Cuba,	1
Georgia,	1
India,	1
Indiana,	1
Japan,	1
Kansas,	1
Maryland,	1
Missouri,	1
Ohio,	1
Oklahoma,	1
Oregon,	1
Virginia,	1
Wyoming,	1
Total,	668

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[1] Work incomplete.

SHORT COURSE STUDENTS, 1915.

THE TEN WEEKS' COURSE.

Adams, Chas. J.,	Arlington.
Aldrich, Leon H.,	Northampton.
Allen, E. B.,	Stockbridge.
Anderson, Mrs. Ernest,	Amherst.
Atkins, Horace K.,	Pleasant Lake.
Bacon, Ralph D.,	Auburn.
Baker, Philip E.,	Norwood.
Barker, Arthur R.,	Littleton.
Barnes, Blakeslee H.,	Yalesville, Conn.
Barnes, James P.,	Yalesville, Conn.
Bates, Fred A.,	Huntington.
Bates, Stacy C.,	Concord Junction.
Bemis, Roger E.,	Spencer.
Bowles, Howard J.,	Springfield.
Bradshaw, Forrest D.,	South Framingham.
Bridgmam, Federal B.,	Westhampton.
Briggs, Harry G.,	Beverly.
Briggs, Leslie W.,	Fitchburg.
Brooks, George R.,	North Grafton.
Brooks, Ida L.,	Worcester.
Brooks, Roger E.,	Worcester.
Buckland, Frederick,	Watertown.
Buckley, W. A.,	Townsend Harbor.
Carr, Ralph W.,	Ashby.
Chapman, E. A.,	Montgomery.
Childs, Stewart I.,	Sunderland.
Clark, Ernest S., Jr.,	Sutton.
Clark, Leonard T.,	Wethersfield, Conn.
Clark, Roderick A.,	Florence.
Clark, William Hobart,	Danvers.
Clary, J. A.,	Conway.
Clem, Katharine L.,	Brooklyn, N. Y.
Colitas, George,	Waltham.
Comstock, Clark P.,	Housatonic.
Coristine, Mrs. Mary S.,	Lee.
Coristine, Walter,	Lee.
Corson, Earl L.,	Okeana, O.
Cox, Fannie A.,	Hyde Park.
Dalrymple, George S.,	Plainfield.
Dana, Alfred L.,	Great Neck, Long Island, N. Y.
Davison, L. B.,	Danby, Vt.
Demirjian, Moses N.,	Bridgewater.
Dorling, Herbert,	Spencer.
Dorsey, John E., Jr.,	North Amherst.
Downs, Winnifred D.,	Springfield.
Dragon, Frank W.,	Northampton.
Drummond, Joseph L.,	Amherst.
Ebersbach, Fador,	Lawrence.
Edwards, Harold,	Dunham, Province of Quebec, Can.
Eldred, George E.,	Bennington, Vt.

Ellis, Charles H.,	Boston.
Ely, Ralph A.,	Holyoke.
Fargo, Frank,	Conway.
Flagg, Maurice,	Littleton Common.
Gala, Andrew,	Greenwich, Conn.
Galligan, Clarence,	New Haven, Conn.
Gardner, Shirley E.,	Pittsfield.
Garrett, Jackson R.,	Concord.
Gaylord, F. B.,	Northampton.
Gee, Harold W.,	Springfield.
Gee, Mrs. Harold W.,	Springfield.
Goff, Henry H.,	Fall River.
Goff, Winslow H.,	Grafton.
Gushee, Almond E.,	Dorchester.
Hall, Louis C.,	Wallingford, Conn.
Hallberg, Carl A.,	Peabody.
Hames, Lawrence B.,	Springfield.
Hamlin, Benj. P.,	Amherst.
Hamlin, Margaret R. P.,	Amherst.
Hammond, Burton N.,	Onset.
Hammond, Charles W.,	Rossville, N. Y.
Hancock, Mrs. Alice H.,	Hyde Park.
Hanley, James F.,	Concord.
Harmount, Dwight Hunt,	Branford, Conn.
Harrington, Ellis T.,	Paxton.
Hopkinson, Harry B.,	Cambridge.
Hubbard, D. B., Jr.,	Middletown, Conn.
Jaspers, Richard,	New Haven, Conn.
Johnson, George L., Jr.,	Pittsfield.
Johnson, Walter C.,	Springfield.
Jones, Mrs. E. A.,	Honolulu, Hawaii.
Kennedy, Florence E.,	New Haven, Conn.
Kennedy, Marguerite I.,	New Haven, Conn.
Keyes, F. G.,	Worcester.
Kimball, Elizabeth,	Arlington.
King, Arthur E.,	Sutton.
Kingman, Robert W.,	Somerville.
Lancy, Benj. C.,	Halifax.
Law, W. P., Jr.,	Lynnfield.
Lee, Margaret D.,	Northampton.
Leonard, William J.,	Ashuelot, N. H.
Levenson, Samuel,	Holyoke.
Livers, Susie D.,	Arlington Heights.
Luther, C. Raymond,	Millbury.
Lyman, Clarence S.,	Gilbertville.
Lyman, F. Brainard,	Grafton.
McConnell, Ralph,	Somerville.
McCray, Carlos,	Monson.
MacDonald, Wm. H.,	Forest Hills.
McKinstry, Joseph H.,	Auburn.
McKirahan, J. E.,	East Ryegate, Vt.
MacLeod, Roderick A.,	Northampton.
Mace, Albert E.,	Wilbraham.
Manning, Charles H.,	Pittsfield.
Marsh, John E.,	Melrose Highlands.
Mathews, L. R.,	Springfield.
Maxwell, Harry,	Elmwood, N. H.
Miller, Donald H.,	Whitman.
Mills, Chester A.,	Pepperell.
Minigan, Everett H.,	Sterling Junction.
Mitchell, Robert A.,	Danvers.
Montgomery, G. Milton, Jr.,	Windsor Locks, Conn.
Moore, Elizabeth F.,	Washington, D. C.
Mosher, Jay M.,	North Attleborough.

Mosher, Samuel M.,	Lakeville.
Nason, Charles A.,	Boston.
Newton, R. L.,	Malden.
Nims, Roger E.,	Montague.
Northrop, Marvin E.,	Three-Mile Bay, N. Y.
Noyes, Walter O.,	Newburyport.
Ogawa, Wasaburo,	Milton.
Ohlson, Carl,	Pittsfield.
Oliver, Wendell F.,	Lynn.
Osgood, John B.,	Orange.
Osgood, Mrs. John B.,	Orange.
O'Toole, Patrick B.,	Waltham.
Owen, Elmer G.,	Paxton.
Parker, Ervine F.,	Poquonock.
Parker, George E.,	East Lynn.
Parsons, Earl M.,	Northampton.
Peck, Fred S.,	South Dayton, N. Y.
Perry, Norman,	Sutton.
Pierce, Harry W.,	Amherst.
Potter, Edward K.,	New Haven, Conn.
Poulin, Alexander, Jr.,	South Lancaster.
Pratt, Walter H.,	Dalton.
Priest, Mrs. Lucia M.,	Allston.
Prior, Leon C.,	Plympton.
Prouty, Ellis F.,	Amherst.
Randall, Alvin R.,	Agawam.
Rhodes, George,	Canaan, Conn.
Richardson, Leroy M.,	Winchester.
Roberts, Ivan A.,	South Lee.
Robinson, John,	Oakham.
Rogers, Helen,	Rochester.
Russell, Edward S.,	Amherst.
Russell, Perley E.,	St. Johnsbury, Vt.
Sanborn, Arthur H.,	Winter Hill.
Sanborn, Ruby,	Beverly.
Schweitzer, Walter,	Jamaica Plain.
Scofield, Ralsey B.,	Greenwich, Conn.
Senter, Everett E.,	Clinton.
Shattuck, George A.,	East Pepperell.
Skinner, Russell,	Brimfield.
Smith, Harry A.,	Bolton.
Smith, Harry A.,	Amherst.
Smith, Walter B.,	West Chesterfield.
Stark, Joseph F.,	West Brattleboro, Vt.
Stickney, F. H.,	Worcester.
Stocking, Charles P.,	Williamstown.
Stockwell, Wm. T.,	Sutton.
Stone, Frederick T.,	Chelsea.
Stone, Robert D.,	Worthington.
Stoughton, Philip,	Montague.
Stowell, A. L.,	Springfield.
Thomas, O. D.,	Brockton.
Tower, Harold M.,	Becket.
True, Fred L.,	Salisbury.
Trumbull, Lymont A.,	Worcester.
Tucker, Henry G.,	Avon.
Tucker, Mrs. Ruth B.,	Avon.
Tufts, James Arthur, Jr.,	Concord.
Turoff, Henry,	Attleboro.
Walpuski, Theodore G., Jr.,	New York City.
Warland, W. S.,	Cambridge.
White, Donald,	Wakefield.
White, Gertrude M.,	Hartford, Conn.
White, Henrique R. F.,	New York City.

Willard, Harold N.,	Roland Park, Md.
Williams, Raymond F.,	Holyoke.
Willis, Nelson B.,	Upton.
Wilson, William A.,	South Hadley.

Summer School of Agriculture and Country Life.

Adams, Ruth A.,	Worcester.
Allanbrook, Mabel C.,	Wilmington.
Armstrong, Mary F.,	West Springfield.
Arnold, John B.,	Tarrytown, N. Y.
Arnold, Mrs. John B.,	Tarrytown, N. Y.
Ayer, Addie M.,	Richford, Vt.
Bailey, Laura H.,	East Saugus.
Bales, Mrs. Harold C.,	North Amherst.
Bau, Mingchie J.,	China.
Bauman, Lucian,	Holyoke.
Bellamy, Mrs. John,	Dorchester.
Bernhardt, Laura,	Harvard.
Beytes, Marion W.,	North Plymouth.
Bleeker, Alethea S.,	Methuen.
Bottume, Hazel E.,	Windsor Locks, Conn.
Brewer, Cyrus,	Scituate.
Brewer, Mrs. Cyrus,	Scituate.
Broad, Gertrude F.,	Gloucester.
Bryant, Bertha W.,	Woburn.
Buckley, Ethel L.,	Needham.
Burk, Emma L.,	Philadelphia, Pa.
Burnap, Margaret,	Woburn.
Burt, Helen F.,	West Somerville.
Carlisle, Edward S.,	Malden.
Carlton, Louise E.,	Williamstown.
Carver, Katharine H.,	Meriden, Conn.
Cassini, Mrs. E.,	Boston.
Chapin, Jennie E.,	Richmond Hill, N. Y.
Cheiffets, Louia,	Worcester.
Chen, H. C.,	Baltimore, Md.
Clark, Frank Y.,	Newton Center.
Clark, W. B.,	Williamstown.
Clarkson, Margaret M.,	Fall River.
Cotton, Edith F.,	Malden.
Cummings, Mary F.,	Boston.
Davis, Ruth A.,	Winter Hill.
Day, Mrs. Clara S.,	New York City.
Demond, Grace E.,	Chicopee Falls.
Denslow, Raymond A.,	Berwyn, Ill.
Doran, Cecilia M.,	Fall River.
Dresser, Henrietta M.,	Haverhill.
Dudley, Sarah A.,	Wollaston.
Dunne, Charles B.,	Brooklyn, N. Y.
Durkee, Dorothy B.,	Worcester.
Eastman, Frances M.,	Amherst.
Edmonds, Mary J.,	Billerica.
Elliot, John,	Groton.
Elliott, S. Maria,	Boston.
Elwell, Susan W.,	Danvers.
Espinosa, Eloisa,	Boston.
Everitt, Mary S.,	Amherst.
Fick, Mrs. H. L. A.,	New York City.
Field, Florence E.,	Gardner.
Flaherty, Marguerite A.,	Hadley.
French, Alice M.,	Lowell.
Frye, Grace E.,	Billerica.
Gaiser, Frederic R.,	New York City.

Gaskill, Marie W.,	Hopedale.
Gavin, Gertrude L.,	Roxbury.
Gavin, Madeline R.,	Roxbury.
Goodnow, Gladys B.,	Fairhaven.
Gray, Isabelle M.,	Somerville.
Grundler, A. J.,	Lowell.
Hall, Mrs. N. L.,	Boston.
Hamilton, Easter I.,	Worcester.
Hardy, Fred C.,	Lancaster.
Harris, Edna M.,	Meriden, Conn.
Helburn, Theresa,	Housatonic.
Henry, Margaret L.,	Norwalk, Conn.
Hobbs, Mary E.,	Fall River.
Hodsdon, Villa,	Cambridge.
Honnay, Agnes,	Amherst.
Hoyt, Minnetta,	East Saugus.
Hoyt, Mrs. Laura A.,	Greenfield.
Hubbard, Alice W.,	Weston.
Hubbard, Olive,	Amherst.
Jackson, Helen,	Brookline.
Jacobs, Adeline H.,	Philadelphia, Pa.
Johns, Lois,	Amherst.
Junkins, Roland,	Eliot, Me.
Kattelle, Fannie M.,	Melrose.
Kebler, Mary W.,	Cincinnati, O.
Keith, Lucy E.,	Gardner.
Kingman, Ruth E.,	Somerville.
Klein, Alice L.,	Thompsonville, Conn.
Laing, Minerva A.,	Granville, N. Y.
Lance, Eva E.,	South Meriden, Conn.
Levin, Ethel H.,	Amherst.
Lewis, Alice,	Meriden, Conn.
Li, K. H.,	China.
Litch, John H.,	New London, N. H.
Ludwig, Irving F.,	Jamaica Plain.
Lyman, Ruth,	North Adams.
McHugh, Ellen,	Boston.
Mandeville, Ernest,	Holyoke.
Mandley, Ethel L.,	New Bedford.
Mason, Isadore H.,	Gardner.
Mathews, Maude A.,	Fall River.
Matson, Nathalie,	Brooklyn, N. Y.
Mellen, Adele L.,	Cambridge.
Mellen, Edwin D.,	Cambridge.
Mellen, J. Edwin,	Cambridge.
Mellen, Lucile C.,	Cambridge.
Mellen, Richard A.,	Cambridge.
Menard, Leon J.,	Holyoke.
Merrill, Earle D.,	Lewiston, Me.
Mitchell, Edw. A.,	Cappahosic, Va.
Monk, Anna C.,	Stoughton.
Morrill, Frances,	Worcester.
Morris, I. Margaret,	Jenkintown, Pa.
Neal, Marie J.,	Pittsfield.
O'Brien, William S.,	Worcester.
Phelon, Lucy M.,	Springfield.
Phillips, Ethel M.,	West Somerville.
Poinier, Helen,	Newark, N. J.
Price, M.,	New York, N. Y.
Putnam, Anna A.,	Worcester.
Rich, Aquila B.,	Maynard.
Ripley, Lena B.,	Belchertown.
Robinson, Mary B.,	Waltham.
Robson, Bertha V.,	Newtonville.

Rome, Edythe,	Worcester.
Rome, Esther,	Gardner.
Rome, Sophie,	Worcester.
Roop, Ruth L.,	Arlington Heights.
Ruggli, Clara W.,	Cambridge.
Ryan, Bridget A.,	Sunderland.
Sanford, Mrs. Alice P.,	Newark, N. J.
Sanford, Molly E.,	Plainfield.
Sawyer, John H.,	North Brookfield.
Schiefner, Frank H.,	Newton Center.
Schindhelm, Sabine C.,	Brooklyn, N. Y.
Sheridan, Anna K.,	Needham.
Sheridan, Mrs. G. F.,	Winchester.
Sheridan, Kathleen,	Winchester.
Short, George T.,	Springfield.
Smith, Edith L.,	Woburn.
Smith, M. Jeannette,	Woburn.
Spencer, Mary W.,	Northampton.
Stebbins, Blanche,	Lexington.
Taylor, Miss Joe,	North Marshfield.
Terry, Julia S.,	Plainfield.
Tranter, Mrs. Lelia E.,	Ware.
Tufts, Frances W.,	New Braintree.
Turner, Arthur W.,	East Templeton.
Turner, George W.,	Roxbury.
Vance, O. F.,	Shelburne, Vt.
Van Sickle, Schuyler,	Springfield.
Walton, Mrs. F. J.,	Cambridge.
Warren, M. Eva,	Auburndale.
Waterman, Edith G.,	Lowell.
Webb, Bessie E.,	Billerica Center.
Webb, Helen M.,	Billerica Center.
Welch, Elizabeth B.,	Fall River.
Wells, Katherine,	Malden.
Wheeler, Ethel M.,	Bridgeport, Conn.
White, Catharine,	Amherst.
White, Helena,	Amherst.
Winchester, Rena,	Shelburne Falls.
Winslow, Edna M.,	Meriden, Conn.
Young, Edwin B.,	Hinsdale, N. H.
Yost, Emma L.,	Meriden, Conn.

School for Rural Social Service.

Anderson, M. T.,	Chesterfield.
Armitage, Frank G.,	Hampden.
Cary, George E.,	Holden.
Crane, Eleanor R. (Mrs.),	Richmond.
Crane, William M.,	Richmond.
Giles, Mrs. L. M.,	Westminster.
Hamlin, Wm. R.,	Hyde Park, Vt.
Hooper, Elisha,	Charlemont.
Hubbard, Horace R.,	Hubbardston.
Ives, Henry S.,	Westhampton.
Mayer-Oakes, S. R.,	Hadley.
Sibley, Horace A.,	Wendell.
Skilton, Emily M.,	Lowell.
Smith, Laura C.,	Berlin, Conn.

School for Library Workers.

Abbott, Mrs. J. T.,	North Wilbraham.
Adriance, Mrs. Carrie E.,	Amherst.
Barber, Edith L.,	Athol.

Berard, Margaret A.,	Turners Falls.
Booth, Mrs. Lucy A.,	Longmeadow.
Capen, Arthur G.,	Worthington.
Chapman, Inez E.,	Amherst.
Collins, Angela W.,	Rockland.
Conway, Ruth E.,	Cleveland, O.
Cooper, Miss,	Greenfield.
Drury, Charlotte H.,	Rutland.
Dunn, Mrs. Jane C.,	Ludlow.
Hastings, Mrs. A. B.,	Warwick.
Hill, Miss,	Greenfield.
Hill, Myra A.,	Williamsburg.
Hord, Dorothy E.,	Turners Falls.
Kellogg, Mary E.,	Granby.
Kingsley, M. Edna,	Monroe Bridge.
Lyman, Ethel L.,	Northampton.
McLauthlen, Mrs. J. F.,	Kingston.
Paige, Fannie S.,	Billerica.
Partenheimer, Louise S.,	Turners Falls.
Robinson, Harriet E.,	Ipswich.
Smith, Mrs. F. H.,	Hadley.
Smith, K. W.,	Middlefield.

Apple Packing School.

Backus, Victor T.,	North Marshfield.
Bowen, Everett A.,	Lakeville.
Chandler, John,	Sterling Junction.
Cogswell, W. Cleveland,	North Scituate.
Elvidge, Avery J.,	North Grafton.
Fenn, Donald F.,	Cambridge.
Foster, Charles H.,	North Andover.
Hall, Fred Porter,	Danvers.
Hitchcock, Charles F.,	Gilbertville.
Kellett, Wilfred L.,	Hopkinton.
Kinney, Frank D.,	Worcester.
Middleton, Frederick H.,	Amherst.
Nelson, Paul G.,	West Newbury.
Patten, Mrs. Robert G.,	Amesbury.
Richardson, Leroy M.,	Winchester.
Tuttle, Donald,	Reading.
Tyler, E. Warren,	Athol.
Walker, Henry P.,	Hudson.
West, Louis J.,	Waterboro, Me.

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Massachusetts Agricultural College

SUPPLEMENT TO THE CATALOGUE

MAY, 1916

PUBLISHED BY THE COLLEGE

CALENDAR

1916-17

Regular Courses.

1916.

January 3, Monday, 1 p. m.	Winter recess ends; regular schedule of classes.
February 7, Monday, 1 p. m.	Second semester begins; regular schedule of classes.
February 22, Tuesday afternoon,	Half holiday, Washington's Birthday.
March 24, Friday, 5 p. m.,	Spring recess begins.
April 3, Monday, 1 p. m.,	Spring recess ends; regular schedule of classes.
April 19, Wednesday afternoon,	Half holiday, Patriots' Day.
May 30, Tuesday,	Holiday, Memorial Day.
June 17-21, Saturday-Wednesday,	Commencement.
June 22-24, Thursday-Saturday,	Entrance examinations.
September 13-16, Wednesday-Saturday,	Entrance examinations.
September 20, Wednesday, 1.30 p. m.,	Fall term begins; chapel.
October 12, Thursday afternoon,	Half holiday, Columbus Day.
November 29, Wednesday, 12 m.—Friday, December 1, 1 p. m.,	Thanksgiving recess.
December 15, Friday, 5 p. m.,	Fall term closes; Christmas recess begins.

1917.

January 1, Monday, 1 p. m.,	Christmas recess ends; winter term begins.
February 22, Thursday afternoon,	Half holiday, Washington's Birthday.
March 23, Friday, 5 p. m.,	Winter term closes; spring recess begins.
April 2, Monday, 1 p. m.,	Spring recess ends; spring term begins.
April 19, Thursday afternoon,	Half holiday, Patriots' Day.
May 30, Wednesday,	Holiday, Memorial Day.
June 23-27, Saturday-Wednesday,	Commencement.
June 27, Wednesday,	Spring term ends.
July 2, Monday,	Summer term begins.
September 19, Wednesday, 1.30 p. m.,	Fall term begins.

FOREWORD

The courses of instruction and program, as outlined in this publication, will become effective in September, 1916, and will be regarded as the official status of the courses for the coming year.

Laboratory fees will be charged in accordance with the principle laid down in the regular catalog, but will not be ready for announcement until the Fall of 1916.

The College reserves the right to withdraw and change the announcements made in this statement.

KENYON L. BUTTERFIELD,
President.

May 20, 1916.

COURSES OF INSTRUCTION

TABLE OF FRESHMAN AND SOPHOMORE SUBJECTS.

The figures indicate the number of credit hours a week. For details, see the descriptions of courses.

FRESHMAN YEAR

First Term

All work required.

Subject	Courses and Numbers	Credit Hours per week
Chemistry	(Chemistry 1 or 4)	3
Algebra	(Mathematics 1)	5
Language	(French or German 1 or 4)	3
English	(English 1)	3
Agriculture & Horticulture	(Agronomy 1, Animal Husbandry 1, Pomology 1, Poultry 1)	2
Tactics	(Military 1)	1
Drill	(Military 4)	1
Hygiene	(Physical Education 1)	1
Public Speaking	(Public Speaking 1) ⅓ of the class	1
College life	(attendance without credit)	20

Second Term

Subject	Courses and Numbers	Credit Hours per week
Chemistry	(Chemistry 2 or 5)	3
Algebra	(Mathematics 2)	2
Trigonometry	(Mathematics 5)	3
Language	(French or German 2 or 5)	3
English	(English 2)	3
Agriculture & Horticulture	(Agronomy 1, Animal Husbandry 1, Pomology 1, Poultry 1)	2
Gymnastics	(Physical Education 5)	1
Geology	(Geology 2)	2
Public Speaking	(Public Speaking 1) ⅓ of class	1
College life	(attendance without credit)	20

Third Term

Subject	Courses and Numbers	Credit Hours per week
Chemistry	(Chemistry 3 or 6)	3
Solid Geometry	(Mathematics 3)	3
Mensuration	(Mathematics 6)	2
Language	(French or German 3 or 6)	3
English	(English 3)	3
Botany	(Botany 3)	3

Tactics	(Military 3)	1
Drill	(Military 6)	1
Public Speaking	(Public Speaking 1) ⅓ of class	1
College life	(attendance without credit)	20

SOPHOMORE YEAR

First Term

Required

Subject	Course Number	Class hr.	2 hour Lab. periods	Credit hours per week
Physics	25	3	1	4
Zoölogy	25	1	2	3
Botany	25	1	2	3
English	25	2	—	2
Military	25	1	—	1
Military	28	—	1	1
			Total required—	14

Elective

Chemistry	25	1	2	3
French	25 or 28	3	—	3
German	25 or 28	3	—	3
Drawing	25	—	3	3
Animal Husbandry	25	2	1	3
Rural Engineering	25	—	2	2

Second Term

Required

Physics	26	2	1	3
Agr. Economics	26	5	—	5
English	26	2	—	2
Physical Ed.	26	—	1	1
				11

Elective

Chemistry	26	1	2	3
French	26 or 29	3	—	3
German	26 or 29	3	—	3
Mathematics	26	2	—	2
Drawing	26	—	3	3
Entomology	26	3	—	3
Animal Husbandry	26	1	2	3
Rural Engineering	26	—	2	2
Botany	26	1	2	3
Econ. Sociology	26	5	—	5

SOPHOMORE YEAR

Third Term

Required

Subject	Course Number	Class hrs.	2 hour Lab. periods	Credit hrs. per week
Rural Sociology	27	3	—	3
Agronomy	27	4	1	5
English	27	2	—	2
Military	27	1	—	1
Military	30	—	1	1
			Total required—	12

Elective

Subject	Course Number	Class hrs.	2 hour Lab. periods	Credit hrs. per week
Chemistry	27	1	4	5
Chemistry	30	3	2	5
French	27 or 30	3	—	3
German	27 or 30	3	—	3
Mathematics	27	—	3	3
Drawing	27	—	3	3
Entomology	27	—	2	2
Geology	27	3	2	5
Physics	27	4	1	5
Horticulture	27	2	1	3
Zoölogy	27	1	2	3

MAJORS: JUNIOR AND SENIOR YEARS

General Statement.

A major consists of 45 credit hours of correlated work, to be arranged by the student and an instructor called the adviser.

The list of courses found under each major on subsequent pages should not be considered as necessarily a rigid program to be followed. The heads of departments have suggested this series of courses as the best for the average man majoring in their departments. Advisers may, however, make modifications to suit the particular needs of the student, provided these modifications conform precisely to the class schedule as published for the year.

Rules governing Majors.

Rule 1. *Election.*—Each student, before the first term of his sophomore year, shall elect a major subject from the list of majors given below; and this major shall consist of 45 credit hours of correlated work.

Rule 2. *Minimum Credits.*—The minimum number of credits for graduation shall be 220 credit hours, inclusive of military drill and physical education.

Rule 3. *Maximum Credits.*—The maximum number of credits for any term of the junior or senior year shall be 21.

Rule 4. *Humanities and Rural Social Science.*—A minimum of 18 credit hours in the Divisions of the Humanities and Rural Social Science will be required of all students during their junior and senior years, with the following restriction: that a minimum of 5 credit hours will be required in each of the divisions.

Rule 5. *Advisers.*—The work of each junior and senior will be under the immediate supervision of an instructor designated as major adviser. Ordinarily, the major adviser will be the head of the department in which the student intends to elect his major. Each student should consult with the adviser as soon as possible. The adviser has full authority to prescribe the student's work up to 45 hours. It is understood, however, that so far as practicable the individual needs of the student will be recognized. It is also hoped and expected that students will be disposed to seek the counsel of the adviser with respect to the remaining courses required for graduation.

Rule 6. *Free Electives.*—Each student during his junior and senior years is required to take 45 hours in his major and also 18 hours in the Divisions of the Humanities and Rural Social Science, making a total of 63 hours. He is allowed free choice of courses to complete his required hours.

Rule 7. *Registration.*—A Sophomore, Junior or Senior shall not register until his major course of study is approved by his adviser.

(1) Course cards for recording the election of majors will be issued from the registrar's office on June 1.

(2) This card must be submitted by each student to his major adviser, who will lay out the course for the year and countersign the card.

(3) Each course card must be filled out, giving the name of student, his college address, the name of parent or guardian, and the student's home address. When the major courses have been entered on this card, and the hours of free elections added by the student, the card must be returned to the registrar not later than June 10.

Rule 8. *Changes.*—Applications for changes may be made to the dean in writing at any time; when approved by him and by the committee on scholarship, they become operative at the beginning of the semester following, provided that no change in the selection of a major may be made by any student after registration day of his senior year.

AGRICULTURE. (MAJOR)

Professor JAMES A. FOORD, *Adviser*

Course	New No.	Cr.
Agronomy . . .	50 **1***	5
Agronomy . . .	76 **3**	5
An. Husbandry . .	51 **3**	5
An. Husbandry . .	75 **1**	3
An. Husbandry . .	76 **2**	3
Dairying	50 **1**	5
Farm Mgt. . . .	75 **2**	3
Farm Mgt. . . .	76 **3**	5
Microbiology . . .	50 **1**	5
or		
Microbiology . . .	50 **3**	
Rural Eng. . . .	75 **1**	5
		44

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	An. Hus. 25	3	Agron. 50	5	An. Hus. 75	3
	Ru. Eng. 25	2	Dairy 50	5	Ru. Eng. 75	5
2	Math. 26	2			Farm Ad. 75	5
	An. Hus. 26	3			An. Hus. 76	3
	Ru. Eng. 26	2				
3	Chem. 30	5	Micro. 50	5	Agron. 76	5
	Math. 27	3	An. Hus. 51	5	Farm Mgt. 76	5
	Hort. 27	3				
4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Animal Husbandry 25 and 26, Rural Engineering (Shop Work) 25 and 26, Chemistry 30, Mathematics 26 and 27, and Horticulture 27.

Additional Information.—Animal Husbandry 50, Dairying 52, Pomology 50 and 51, Rural Engineering 78, and Veterinary 51 are suggested as additional courses for the student fitting himself for general agriculture.

AGRONOMY. (MAJOR)

Professor SIDNEY B. HASKELL, *Adviser*

Course	New No.	Cr.
Agronomy . . .	50 **1***	5
Agronomy . . .	51 **3**	5
Agronomy . . .	75 **1**	5
Agronomy . . .	77 **2**	5
An. Husb. . . .	75 **1**	3
Chemistry . . .	51 **1**	8
Chemistry . . .	52 **2**	8
Farm Mgt. . . .	76 **3**	5
		— 44

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	Chem. 25 25 Germ. or 28	3 3	Agron. 50 Chem. 51	5 8	Agron. 75 An. Hus. 75	5 5
2	Bot. 26 Chem. 26 26 Germ. or 29 Math. 26	3 3 3 2	Chem. 52	8	Agron. 77	5
3	27 Germ. or 30 Math. 27 Geol. 27	3 3 5	Agron. 51	5	Farm Mgt. 76	5
4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Chemistry 25 and 26, German 25 or 28, 26 or 29, 27 or 30, Geology 27, Botany 26. Advised.—Mathematics 26 and 27.

ANIMAL HUSBANDRY. (MAJOR)

Professor JOHN C. MCNUTT, *Adviser*

Course	New No.	Cr.	Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
Agronomy . . .	50 **1***	5	**1**	An. Hus. 25	3	Agron. 50	5	An. Hus. 75	3
						Vet. 50	5		
An. Husbandry . .	51 **3**	5				Dairy. 50	5		
An. Husbandry . .	50 **2**	1							
An. Husbandry . .	52 **3**	3	**2**	An. Hus. 26	3	An. Hus. 50	1	An. Hus. 76	3
								An. Hus. 78	3
An. Husbandry . .	75 **1**	3						Farm Mgt. 75	3
An. Husbandry . .	76 **2**	3							
An. Husbandry . .	77 **3**	3	**3**	Chem. 30	5	An. Hus. 51	5	An. Hus. 80	1
						An. Hus. 52	3	An. Hus. 77	3
An. Husbandry . .	78 **2**	3						Farm Mgt. 76	5
An. Husbandry . .	80 **3**	1							
Dairying	50 **1**	5	**4**						
Farm Mgt. . . .	75 **2**	3							
Farm Mgt. . . .	76 **3**	5							
Veterinary . . .	50 **1**	5							
		45							

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Animal Husbandry 25 and 26, Chemistry 30.
Additional Information.—The balance of the Sophomore electives allowed are left to the student to choose.

DAIRYING. (MAJOR)

Professor WILLIAM P. B. LOCKWOOD, *Adviser*

Course	New No.	Cr.
Animal Husb. . . .	52 **3***	3
Animal Husb. . . .	75 **1**	3
Animal Husb. . . .	76 **2**	3
Dairying	50 **1**	5
Dairying	51 **3**	5
Dairying	75 **2**	5
Dairying	76 **3**	5
Farm Mgt. . . .	75 **2**	3
Microbiology . . .	50 **1**	5
Microbiology . . .	82 **1**	5
Rural Eng. . . .	77 **2**	5
		47

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	An. Hus. 25	3	Dairy. 50	5	An. Hus. 75	3
	Ru. Eng. 25	2	Micro. 50	5	Micro. 82	5
2	An. Hus. 26	3	Ru. Eng. 77	5	Farm Mgt. 75	3
	Ru. Eng. 26	2	Micro. 51	5	An. Hus. 76	3
			(Preq. to 82)		Dairy. 75	5
3	Chem. 30	5	An. Hus. 52	3	Dairy. 76	5
			Dairy. 51	5		
4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Animal Husbandry 25 and 26, Rural Engineering 25 and 26, Chemistry 30.
Additional Information.—The balance of the Sophomore electives allowed are left to the student to choose.

POULTRY HUSBANDRY. (MAJOR)

Professor JOHN C. GRAHAM, *Adviser*

Course	New No.	Cr.
Agronomy	50 **1***	5
Animal Husb.	51 **3**	5
Poultry Husb.	50 **1**	3
Poultry Husb.	51 **1**	2
Poultry Husb.	52 **2**	3
Poultry Husb.	53 **3**	5
Poultry Husb.	54 **3**	2
Poultry Husb.	75 **2**	5
Poultry Husb.	76 **1**	5
Poultry Husb.	77 **1**	5
Veterinary Sc.	85 **1**	3
Veterinary Sc.	86 **2**	3
		46

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1			Poult. 50 Poult. 51 Agron. 50	3 2 5	Poult. 76 Poult. 77 Vet. 85	5 5 3
2			Poult. 52	3	Poult. 75 Vet. 86	5 3
3			Poult. 53 Poult. 54 An. Hus. 51	5 2 5		
4						

*The heavy faced type indicates the term in which the course is given.

Additional Information.—The Sophomore electives allowed are left to the student to choose.

FLORICULTURE. (MAJOR)

Associate Professor ARNO H. NEHRLING, *Adviser*

Course	New No.	Cr.
Botany	50 **1***	2
Botany	51 **2**	2
Entomology . . .	26 **2**	3
Floriculture . . .	50 **1**	4
Floriculture . . .	51 **2**	4
Floriculture . . .	52 **3**	4
Floriculture . . .	53 **1**	3
Floriculture . . .	75 **1**	3
Floriculture . . .	76 **3**	3
Floriculture . . .	77 **2**	3
Floriculture . . .	78 **3**	3
Horticulture . . .	50 **1**	5
Horticulture . . .	51 **3**	5
		44

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	Drawing 25	3	Flori. 50	4	Flori. 75	3
			Flori. 53	3	Hort. 50	5
			Bot. 50	2		
2	Drawing 26	3	Flori. 51	4	Flori. 77	3
	Ent. 26	3	Ent. 26	5		
	Botany 26	3	Bot. 51	2		
3	Drawing 27	3	Flori. 52	4	Flori. 76	3
	Ent. 27	2			Flori. 78	3
	Hort. 27	3			Hort. 51	5
4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Drawing 25, 26 and 27; Entomology 26 and 27; Botany 26 and Horticulture 27.

Additional Information.—The balance of the Sophomore electives allowed are left to the student to choose. Horticulture 50 and 51 will be taken by seniors.

FORESTRY. (MAJOR)

Professor WILLIAM D. CLARK, *Adviser*

Course	New No.	Cr.
Botany	84 **2***	5
Botany	85 **3**	5
Entomology	75 **1**	4
Forestry	50 **1**	3
Forestry	51 **2**	3
Forestry	53 **3**	3
Forestry	75 **1**	5
Forestry	78 **3**	3
Horticulture	50 **1**	5
Horticulture	51 **3**	5
Land. Gard.	50 **1**	5
		46

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	Draw. 25	3	Forst. 50	3	Forst. 75	5
	Ru. Eng. 25	2	L. Gard. 50	5	Ent. 75	4
			Hort. 50	5		
2	Draw. 26	3	Forst. 51	3	Bot. 84	5
	Math. 26	2				
	Ent. 26	3				
	Bot. 26	3				
3	Draw. 27	3	Forst. 53	3	Bot. 85	5
	Math. 27	2	Hort. 51	5	Forst. 78	3
	Ent. 27	3				
	Hort. 27	3				
4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Drawing 25, 26 and 27, Rural Engineering 25, Mathematics 26 and 27, Entomology 26 and 27, Botany 26, Horticulture 27.

LANDSCAPE GARDENING. (MAJOR)

Professor FRANK A. WAUGH, *Adviser*

Course	New No.	Cr.
Horticulture . . .	50 **1***	5
Horticulture . . .	51 **3**	5
Land. Gard. . . .	50 **1**	5
Land. Gard. . . .	51 **2**	4
Land. Gard. . . .	52 **3**	5
Land. Gard. . . .	53 **4**	5
Land. Gard. . . .	75 **1**	3
Land. Gard. . . .	76 **2**	4
Land. Gard. . . .	77 **3**	4
Land. Gard. . . .	78 **3** or 79 **3**	3
		43

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	Draw. 25	3	L. Gard. 50	5	L. Gard. 75	3
			Hort. 50	5		
			Draw. 25	3		
2	Draw. 26	3	L. Gard. 51	4	L. Gard. 76	4
	Math. 26	2	Draw. 26	3		
	Ent. 26	3				
3	Draw. 27	3	L. Gard. 52	5	L. Gard. 78 or 79	3
	Math. 27	3	Hort. 51	5		
	Hort. 27	3	Draw. 27	3	L. Gard. 77	4
4			L. Gard. 53	5		

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Drawing 25, 26 and 27, Mathematics 26 and 27, Horticulture 27. Advised, Entomology 26.

Additional Information.—Juniors in 1916-17 required to take Drawing 25, 26 and 27.

POMOLOGY. (MAJOR)

Professor FRED C. SEARS, *Adviser*

Course	New No.	Cr.
Agronomy	75 **1***	5
Botany	50 **1**	2
Botany	51 **2**	2
Entomology . . .	26 **2**	3
Entomology . . .	27 **3**	2
Pomology	50 **1**	3
Pomology	51 **2**	3
Pomology	52 **3**	3
Pomology	75 **1**	3
Pomology	76 **2**	3
Pomology	77 **1**	5
Pomology	78 **3**	3
		37

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	Ru. Eng. 25	2	Pom. 50 Bot. 50	3 2	Pom. 75 Pom. 77 Agron. 75	3 5 5
2	Bot. 26 Ru. Eng. 26 Ent. 26	3 2 3	Pom. 51 Bot. 51 Ent. 26	3 2 5	Pom. 76	3
3	Hort. 27 Ent. 27	3 2	Pom. 52 Ent. 27	3 3	Pom. 78	3
4			Pom. 53	3		

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Horticulture 27, Entomology 26 and 27, Botany 26.
Advised.—Rural Engineering 25 and 26.
Additional Information.—The balance of the Sophomore electives allowed are left to the student to choose.

ECONOMIC BOTANY. (MAJOR)

Professor A. VINCENT OSMUN, *Adviser*

Course	New No.	Cr.	Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
Botany	52 **1****	3		Chem. 25	3	Bot. 52	3	Bot. 75	5
Botany	53 **2**	3	1	25		Bot. 55	3	Bot. 78	5
Botany	54 **3**	3		Germ. or	3	Chem. 51	8	Bot. 86	1
Botany	55 **1**	3		28					
Botany	56 **2**	3							
Botany	75 **1**	5							
Botany	76 **2**	5		Chem. 26	3	Bot. 53	3	Bot. 76	5
Botany	77 **3**	5	2	26		Bot. 56	3	Bot. 79	5
Botany	78 **1**	5		Germ. or	3			Bot. 82	3
Botany	79 **2**	5		29				Bot. 87	1
Botany	80 **3**	5		Bot. 26	3				
Botany	82 **2**	3							
Botany	83 **3**	3		27		Bot. 54	3	Bot. 77	5
Botany	86 **1**	1	3	Germ. or	3			Bot. 80	5
Botany	87 **2**	1		30				Bot. 83	3
Botany	88 **3**	1						Bot. 88	1
Chemistry . . .	51 **1**	8							
		62	4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—German 25 or 28, 26 or 29, 27 or 30, Botany 26.
Advised.—Chemistry 25 and 26.
Additional Information.—The balance of the Sophomore electives allowed are left to the student to choose.
Selection of 45 credits of the above (Pathology 75, 76 and 77; Physiology 78, 79 and 80).

AGRICULTURAL CHEMISTRY. (MAJOR)

Associate Professor CHARLES A. PETERS, *Adviser*

Course	New No.	Cr.
Chemistry . . .	51 **1***	8
Chemistry . . .	52 **2**	8
Chemistry . . .	60 **1**	3
Chemistry . . .	61 **2**	3
Chemistry . . .	62 **3**	3
Chemistry . . .	65 **3**	5
Chemistry . . .	76 **1**	5
Chemistry . . .	77 **2**	3
Chemistry . . .	80 **1**	5
Chemistry . . .	87 **3**	3
Chemistry . . .	90 **2**	
Chemistry . . .	92 **2**	3
Chemistry . . .	94 **2**	
Chemistry . . .	91 **3**	
Chemistry . . .	93 **2**	5
Chemistry . . .	95 **3**	
		— 54**

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1	Chem. 25 25 Germ. or 28	3 3	Chem. 51 Chem. 60	8 3	Chem. 76 Chem. 80	5 5
2	Chem. 26 26 Germ. or 29 Ent. 26	3 3 3	Chem. 52 Chem. 61	8 3	Chem. 77 Chem. 90, 92, 94	3 3
3	Chem. 27 27 Germ. or 30 Ent. 27	5 3 2	Chem. 62 Chem. 65	3 5	Chem. 91, 93, 95 Chem. 87	5 3
4						

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Chemistry 25, 26 and 27.
Advised.—German 25 or 28, 26 or 29, 27 or 30, Entomology 26 and 27.
Additional Information.—The balance of the Sophomore electives allowed are left for the student to choose.

**To get the allowed 45 credits the student will select one of the following groups of courses: 90 and 91, or 92 and 93, or 94 and 95 together with the balance from courses shown above.

ECONOMIC ENTOMOLOGY. (MAJOR)

Professor HENRY T. FERNALD, *Adviser*

Course	New No.	Cr.	Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
Botany	50 **1***	2		French 25-28		Bot. 50	2	Ent. 76	5
			1	or	3	Zoo. 50	3		
Entomology	26 **2**	3		Germ. 25-28					
				Chem. 25	3				
Entomology	27 **3**	2							
Entomology	75 **3**	4		French 26-29		Ent. 26	3	Ent. 77	3
			2	or	3	Zoo. 51	3	Zoo. 76	3
Entomology	76 **1**	5		Germ. 26-29				Ent. 90	3
				Ent. 26	3				
Entomology	77 **2**	3		Bot. 26	3				
Entomology	78 **3**	4		French 27-30		Ent. 27	2	Ent. 78	4
			3	or	3	Zoo. 52	3	Ent. 75	4
Entomology	90 **2**	3		Germ. 27-30					
				Ent. 27	2				
Zoölogy	50 **1**	3		Zoo. 27	3				
Zoölogy	51 **2**	3							
			4						
Zoölogy	52 **3**	3							
Zoölogy	54 **2**	3							
		38							

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—Entomology 26 and 27, Zoölogy 27, Botany 26.
Advised.—French or German 25 or 28, 26 or 29, 27 or 30; Chemistry 25.
Additional Information.—The balance of the Sophomore electives allowed are left for the student to choose. Juniors are advised to take Entomology 60. In 1916-17, Entomology 26 and 27 will be taken by Juniors as part of their major. Beginning 1917-18, the regular Junior courses 50, 51 and 52 will be in operation.

Professor Charles E. Marshall, *Adviser*

Course	New No.	Cr.	Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
Chemistry . . .	51 **1***	8		Chem. 25	3	Micro. 50	5	Micro. 81	5
			1	25		Micro. 51	5	Micro. 82	5
Chemistry . . .	52 **2**	8		Germ. or	3	Chem. 51	8	Micro. 83	5
				28					
Microbiology . . .	50 **1**								
or		5							
Microbiology . . .	50 **3**								
				Chem. 26	3	Micro. 51	5	Micro. 75	5
Microbiology . . .	51 **1**		**2**	26		Chem. 52	8	Micro. 80	5
or				Germ. or	3			Dairy. 75	5
Microbiology . . .	51 **2**	5		29					
or									
Microbiology . . .	51 **3**								
				Chem. 27	5	Micro. 50	5	Micro. 76	5
Microbiology . . .	52 **3**	5	**3**	27		Micro. 51	5		
				Germ. or	3	Micro. 52	5		
Microbiology . . .	81 **1**			30					
or									
Microbiology . . .	82 **1**	5							
or									
Microbiology . . .	83 **1**		**4**						
Microbiology . . .	80 **2**								
or									
Microbiology . . .	75 **2**	5							
or									
Dairying	75 **1**								
		41							

*The heavy faced type indicates the term in which the course is given.

Sophomore Elective Prerequisites: Required.—German 25 or 28, 26 or 29, 27 or 30, Chemistry 25, 26 and 27.
Additional Information.—The balance of the Sophomore electives allowed are left for the student to choose. Microbiology 51, Fall term, will be taken by

RURAL JOURNALISM. (MAJOR)

Associate Professor ROBERT W. NEAL, *Adviser*

Course	New No.	Cr.
R. Journalism . . .	50 **1***	3
R. Journalism . . .	51 **2**	3
R. Journalism . . .	52 **3**	3
R. Journalism . . .	53 **1**	3
R. Journalism . . .	54 **2**	3
R. Journalism . . .	55 **3**	3
R. Journalism . . .	77 **1**	3
R. Journalism . . .	78 **2**	3
R. Journalism . . .	79 **3**	3
R. Journalism . . .	80 **1**	4 or 5
R. Journalism . . .	81 **2**	4 or 5
R. Journalism . . .	82 **3**	4 or 5
		39-42

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1			Journ. 50	3	Journ. 77	3
			Journ. 53	3	Journ. 80	4-5
			Agr. Sc. 51	5		
2			Journ. 51	3	Journ. 78	3
			Journ. 54	3	Journ. 81	4-5
			Ec. Soc. 51	5		
3			Journ. 52	3	Journ. 79	3
			Journ. 55	3	Journ. 82	4-5
4						

*The heavy faced type indicates the term in which the course is given.

Additional Information.—The Sophomore electives allowed, are left to the students to choose. Major students will take two courses of the groups 50, 51 and 52; 53, 54 and 55; and 77, 78 and 79. The adjustments will be made according to the individual case. Groups 80, 81 and 82 will ordinarily be taken for the full three terms. For the remaining part of the 45 required major credits the student will take Economic Sociology 51 and Agricultural Economics 51, and elect from the following: Economic Sociology 26, Advanced French, German, Spanish, English Literature, History and Government 76, Entomology 90 and certain other courses especially suitable in the different divisions.

AGRICULTURAL ECONOMICS. (MAJOR)

Professor ALEXANDER E. CANCE, *Adviser*

Course	New No.	Cr.	Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
Agri. Economics	50 **1***	5	**1**			Agr. Ec. 50	5	Agr. Ec. 75	5
Agri. Economics	52 **2**	5							
Agri. Economics	75 **1**	5							
Agri. Economics	76 **2**		**2**			Agr. Ec. 52	5	Agr. Ec. 76	5
or		5				Ru. Soc. 51	3	Ru. Soc. 78	5
Agri. Economics	77 **3**					Ec. Soc. 51	5		
Ec. Sociology	51 **2**	5							
Ec. Sociology	52 **3**	5	**3**			Ec. Soc. 52	5	Farm Mgt. 76	5
						Ru. Soc. 52	3	Agr. Ec. 77	5
Farm Mgt.	76 **3**	5							
Rural Sociology	51 **2**	3							
Rural Sociology	52 **3**	3	**4**						
Rural Sociology	78 **2**	5							
		46							

*The heavy faced type indicates the term in which the course is given.

Additional Information.—The Sophomore electives allowed are left to the student to choose.

AGRICULTURAL EDUCATION. (MAJOR)

Professor WILLIAM R. HART, *Adviser*

Course	New No.	Cr.
Agri. Education . .	50 **1***	5
Agri. Education . .	51 **2**	5
Agri. Education . .	52 **4**	5
Agri. Education . .	53 **3**	5
Agronomy . . .	50 **1**	5
Agronomy . . .	75 **1**	5
Botany	50 **1**	2
Botany	51 **2**	2
Dairying	77 **1**	5
Farm Mgt. . . .	75 **2**	3
Mark. Gard. . . .	50 **3**	3
Pomology	50 **1**	3
Poultry Husb. . . .	50 **1**	3
		51

Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
1			Bot. 50	2	Agron. 75	5
			Agr. Ed. 50	5	Poult. 50	3
			Agron. 50	5	Dairy. 77	5
			Pom. 50	3		
2			Agr. Ed. 51	5	Farm Mgt. 75	3
			Bot. 51	2		
3			M. Gard. 50	3		
			Agr. Ed. 53	5		
4			Agr. Ed. 52	5		

*The heavy faced type indicates the term in which the course is given.

Additional Information.—The Sophomore electives allowed are left to the student to choose.
Substitutions of other technical courses for some of those above mentioned may be made to meet the needs of individual students.
A selection is allowed of Poultry Husbandry 50 and Market Gardening 50, making 6 credits, or Agronomy 75, 5 credits, making the total credits 45 or 46.

RURAL SOCIAL SCIENCE. (MAJOR)

Professor JOHN PHELAN, *Adviser*

Course	New No.	Cr.	Term	Sophomore	Cr.	Junior	Cr.	Senior	Cr.
Agri. Economics . .	50 **1***	5				Agr. Ec. 50	5	Ru. Soc. 75	3
			1			Agr. Ec. 51	5		
Agri. Economics . .	51 **1**	5				Ru. Soc. 50	3		
Ec. Sociology . . .	51 **2**	5							
Ec. Sociology . . .	76 **3**	5				Ru. Soc. 51	3	Ru. Soc. 77	3
			2			Agr. Ed. 52	5	Hst. & Gvt. 75	3
Hist. & Govt. . . .	75 **2**	3				Ec. Soc. 51	5	Ru. Soc. 78	5
Rural Journalism . .	55 **3**	3							
Rural Sociology . .	50 **1**	3				Ru. Journ. 55	3	Ru. Soc. 75	3
			3			Ru. Soc. 52	3	Ec. Soc. 76	5
Rural Sociology . .	52 **3**	3							
Rural Sociology . .	51 **2**	3							
Rural Sociology . .	77 **2**	3							
			4						
Rural Sociology . .	75 **1**								
or		3							
Rural Sociology . .	75 **3**								
Agri. Education . .	52 **2**								
or		5							
Rural Sociology . .	78 **2**								
		46							

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*The heavy faced type indicates the term in which the course is given.

Additional Information.—The Sophomore electives allowed are left to the student to choose.

DIVISION OF AGRICULTURE.

Professor Foord.

Agronomy.

Professor Haskell, Assistant Professor Jones, Mr. Merkle, Mr. Cobb.

1. **1 and 2.** AGRONOMY.—Freshman. Given as part of the Freshman Agriculture and Horticulture. This course aims, by actual contact with the plants and their products, to make the student familiar with the most common farm crops of Massachusetts and their uses. The crops studied are maize, cereals, grasses, legumes, potatoes and root crops. Six weeks, part of class only, 1st Term; balance of class six weeks during the 2nd Term.

2 2-hour laboratory periods, credit 1.
Assistant Professor Jones and Assistants.

27. **3.** SOILS AND FERTILIZERS.—Sophomores. A study of the soils and their properties, soil management, methods of soil improvement and maintenance of fertility, including the use of farm manures, commercial fertilizers and soil amendments.

4 class hours. 1 2-hour laboratory period, credit 5.
Professor Haskell and Assistants.
Prerequisite, Freshman required chemistry.

50. **1.** FIELD AND FORAGE CROPS.—For Juniors, Seniors may elect. History, classification and production of maize and of those grasses, legumes, forage and root crops suited to New England conditions. The work includes lecture, laboratory and field study of these various crops.

2 class hours. 3 2-hour laboratory periods, credit 5.
Assistant Professor Jones and Mr. Cobb.
Prerequisites, Agronomy 27, Botany 3.

51. **3.** ADVANCED FIELD CROPS.—For Juniors, Seniors may elect. A study of the cereal grains, with lectures, laboratory and field study of the purity, quality and vitality of the seeds of farm crops and the handling, grading and judging of their products.

3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor Jones and Mr. Cobb.
Prerequisite, Agronomy 50.

75. **1.** ADVANCED SOILS.—For Seniors, Juniors may elect. A field, lecture and laboratory course on soils and their adaptability to different uses. The field work consists of a detailed soil survey of the college farm and other areas, followed by a laboratory study of the physical properties of soils collected.

2 class hours. 3 2-hour laboratory periods, credit 5.
Professor Haskell and Mr. Merkle.
Prerequisite, Agronomy 27.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:
1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

76. **3.** DRAINAGE AND IRRIGATION.—For Seniors, Juniors may elect. A field and lecture course on soil improvement by drainage and irrigation with special reference to problems of this nature as faced by Massachusetts farmers.

2 class hours. 1 2 and 1 4-hour laboratory period, credit 5.
Professor Haskell and Mr. Merkle.

Prerequisites, Mathematics 26 and 27, Agronomy 27.

77. **2.** MANURES AND FERTILIZERS.—Seniors. An advanced course, giving a general discussion of the different theories which have been held relative to the functions and importance of manures and fertilizers, and leading up to the views at present accepted. Considerable attention is devoted to consideration of the experimental work which has been done, and which is now in progress.

4 class hours. 1 2-hour laboratory period, credit 5.
Professor Haskell.

Prerequisite, Agronomy 27.

78. **2.** BREEDING OF FIELD CROPS.—Seniors. This course deals with the improvement, by selection and breeding, of the crops studied in Courses 50 and 51.

3 class hours.
Assistant Professor Jones.

Prerequisite, Agronomy 51.

ANIMAL HUSBANDRY.

Professor McNutt, Assistant Professor Quaife, Mr. Fish.

1. **1 and 2.** ANIMAL HUSBANDRY.—Freshman. Given as part of the Freshman Agriculture and Horticulture. This course is outlined to give the student a greater appreciation of animal husbandry. Demonstrations will be given and judging will be done to familiarize the student with the various breeds and market classes. Six weeks, part of class only, 1st Term; balance of class six weeks during the 2nd Term.

2 2-hour laboratory periods, credit 1.
Animal Husbandry Department.

25. **1.** BREEDS AND TYPES OF LIVE STOCK.—Sophomores. A course covering the origin, history, development and characteristics of the different breeds of horses, cattle, sheep and swine. Text-book, Plumb's "Breeds and Types of Farm Animals."

1 lecture. 2 2-hour laboratory periods, credit 3.
Assistant Professor Quaife.

26. **2.** BREEDS AND TYPES OF LIVE STOCK.—Sophomores. Continuation of Course 25.

1 lecture. 2 2-hour laboratory periods, credit 3.
Assistant Professor Quaife.

Prerequisite, Animal Husbandry 25.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

50. **2.** LIVE STOCK MANAGEMENT.—For Juniors, Seniors may elect. The work of this course consists of laboratory work by the individual students in the handling of live stock; with horses, such work as halter breaking, harnessing, casting and fitting for show will be done; similarly, the practical handling of cattle, sheep and swine will be fully treated. Special study is given to halter making, splicing, hitches, knots and all rope work.

1 2-hour laboratory period, credit 1.
Assistant Professor QUAIFE.

Prerequisites, Animal Husbandry 25 and 26.

51. **3.** PRINCIPLES OF BREEDING.—For Juniors, Seniors may elect. This course is designed to familiarize the student with the problems involved in animal and plant improvement; to acquaint him with the facts which are already established; to scrutinize prevailing theories; and to indicate the lines and methods of further work. Some of the subjects studied are: variations, their causes and heritability; DeVrie's theory of mutations; the inheritance of acquired characters; the pure line; Mendelian law; the making of new types: the determination of sex; applications to human heredity. A few periods at the end of the course are devoted especially to the application of principles in live stock improvement. "Genetics," by Herbert E. Walter. Supplementary reading.

5 class hours. Credit 5.
Professor McNUTT.

Prerequisite, Zoology 25.

52. **3.** ADVANCED STOCK JUDGING.—For Juniors, Seniors may elect. This course is designed to equip animal husbandry students in the judging of classes of different types of live stock; to strengthen them in the selection of superior sires; and equip them for stock judging at fairs. Visits will be made to the best herds for the various breeds of stock in the State. Judging teams to represent the college will be selected largely from this class.

1 2 and 1 4-hour laboratory period, credit 3.
Professor McNUTT.

Prerequisite, Animal Husbandry 50.

75. **1.** FEEDING AND MANAGEMENT.—For Seniors, Juniors may elect. A study of the principles of animal nutrition; of the composition and qualities of feeding materials. Text-book, Henry's "Feeds and Feeding."

3 class hours. Credit 3.
Assistant Professor QUAIFE.

Prerequisite, Chemistry 30 or 51.

76. **2.** FEEDING AND MANAGEMENT.—For Seniors, Juniors may elect. A study of the feeding, care and management of dairy cattle from birth to maturity, with especial attention to economic production. Text-book, Henry's "Feeds and Feeding."

3 class hours. Credit 3.
Professor McNUTT.

Prerequisite, Chemistry 30 or 51.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

77. **3.** FEEDING AND MANAGEMENT.—For Seniors, Juniors may elect. A continuation of Courses 75 and 76, dealing in a similar manner with horses, sheep, beef cattle and swine.
3 class hours. Credit 3.
Assistant Professor QUAIFE.

Prerequisite, Animal Husbandry 75.

78. **2.** HERD AND STUD-BOOK STUDY.—For Seniors, Juniors may elect. An advanced course in the study of the breeds of live stock, familiarizing the student with the detailed history of the breed, the most productive sires and dams of the various breeds, and the successful lines and methods of breeding.
1 class hour. 2 2-hour laboratory periods, Credit 3.
Professor McNUTT.

Prerequisite, Animal Husbandry 75.

80. **3.** SEMINAR.—For Seniors majoring in Animal Husbandry only. Advanced study upon questions pertaining to live stock and live stock production. Each student electing this work will choose some particular line of work in which he is specially interested, and will pursue study in this subject by reading, compilation and research. There will be no regular lecture period, but seminars will be held. A satisfactory report of the results must be presented in a thesis.
1 2-hour laboratory period, credit 1.
Professor McNUTT.

DAIRYING.

Professor LOCKWOOD, Assistant Professor JAMISON, MR. COONS, MR. BALDINGER.

Elective Courses.

50. **1.** MILK AND MILK COMPOSITION.—For Juniors, Seniors may elect. The development of the dairy business in the United States; the composition, secretion and general characteristics of milk; contamination and fermentation; the study of analysis of milk products by use of the Babcock test for fat, tests for acidity and adulteration, and ordinary preservatives; moisture tests for butter; methods for testing herds and developing them to higher efficiency; problems.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor JAMISON and the DEPARTMENT.

51. **3.** BUTTERMAKING.—For Juniors, Seniors may elect. A study of separators and cream separation; handling milk and cream for buttermaking; preparation of starters, and ripening cream; churning; markets and their requirements; marketing, scoring and judging butter; management; problems; dairy machinery and care thereof.
2 class hours. 2 3-hour laboratory periods, credit 5.
MR. COONS and the DEPARTMENT.

Prerequisite, Dairying 50.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

75. **2.** MARKET MILK.—For Seniors, Juniors may elect. A study of market milk conditions; extent and development of the business; supply and delivery; food value of milk and its uses as food; milk and its relation to the public health; proper methods for handling milk and cream for direct consumption; certified milk, requirements and production; pasteurizing; sterilizing; standardizing and modifying; milk laws and inspection.
3 class hours. 2 2-hour laboratory periods, credit 5.
Professor LOCKWOOD and the DEPARTMENT.
Prerequisite, Dairying 50.

76. **3.** MILK PRODUCTS.—For Seniors, Juniors may elect. The manufacture of milk products other than butter, including cheddar cheese, soft and fancy cheese, ice cream, condensed milk, casein, milk powder, etc. Laboratories, largely the making of soft and fancy cheese and ice cream.
2 class hours. 2 3-hour laboratory periods, credit 5.
MR. BALDINGER.
Prerequisite, Dairying 75.

77. **1.** DAIRYING.—For Seniors, Juniors may elect. A course designed primarily for teachers of secondary agriculture. The work given will cover briefly the composition and secretion of milk, the Babcock fat test, the relation of bacteria to dairy work and principles of creaming; separators; elementary buttermaking; proper methods of handling milk and cream; and the relation of market milk to the public health.
3 lecture hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor JAMISON and the DEPARTMENT.

FARM MANAGEMENT

Professor FOORD, MR. PEACOCK.

Elective Courses.

75. **2.** FARM AND COST ACCOUNTING.—For Seniors, Juniors may elect. A study of the principles of accounting and their application to the large or small farm. Actual practice with records and cost accounting.
1 class hour. 2 2-hour laboratory periods, credit 3.
Professor FOORD, MR. PEACOCK.

76. **3.** FARM MANAGEMENT.—For Seniors, Juniors may elect. The organization of the farm as a business enterprise. A discussion and study of some of the problems that confront the modern farmer, such as the choice of a farm, systems and types of farming, labor, marketing, records and farm accounts.
3 class hours. 2 2-hour laboratory periods, credit 5.
Professor FOORD.
Prerequisites, Agronomy 50, Animal Husbandry 25 and 26.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:
1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

POULTRY HUSBANDRY.

Professor Graham, Dr. Goodale, Mr. Payne.

1. **1 and 2.** POULTRY HUSBANDRY.—Freshman. Given as part of the Freshman Agriculture and Horticulture. This course consists of a study of the characteristics of the most important breeds and varieties of poultry based upon the classification in the Standard of Perfection. This will embrace both standard and utility qualities. The work on comparison will be based on the key. A special score card will be used for utility judging. Attention will be given to the adaptation of the most popular varieties, to the more highly specialized lines of poultry culture and to the part played by poultry in New England agriculture. Six weeks, part of class only, 1st Term; balance of class six weeks during the 2nd Term.

2 2-hour laboratory periods, credit 1.
Poultry Department.

Elective Courses.

50. **1.** ELEMENTS OF POULTRY CULTURE.—For Juniors, Seniors may elect. This course consists of a comprehensive study of poultry-house construction, poultry-house equipment, feeds and feeding, winter-egg production, types and breeds of poultry.

3 class hours. Credit 3.
Professor Graham.

51. **1.** POULTRY PRACTICE WORK.—For Juniors, Seniors may elect. This is a practical laboratory course in poultry carpentry, caponizing, killing and picking; dressing and packing poultry, sorting and preparing eggs for market.

2 2-hour laboratory periods, credit 2.
Mr. Payne.

Prerequisite: Must be accompanied by Poultry 50.

52. **2.** ELEMENTS OF POULTRY CULTURE.—For Juniors, Seniors may elect. This course treats the subjects of incubation, brooding, care of growing stock, breeding, market poultry, including capons, roasters and broilers, and diseases of poultry.

3 class hours. Credit 3.
Professor Graham.

Prerequisite, Poultry 50.

53. **3.** INCUBATION AND BROODING.—For Juniors, Seniors may elect. In this course students are required to set up and operate incubators and brooders, make a systematic study of the development of the chick in the egg, and the care of sitting hens. Laboratory time by arrangement.

1 class hour. 4 2-hour laboratory periods, credit 5.
Mr. Payne.

Prerequisite, Poultry 52.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

54. **3.** PEN MANAGEMENT.—For Juniors, Seniors may elect. This is a practical laboratory course. Students are required to care for a pen of fowls, keeping accurate records of eggs produced, food consumed, weather conditions, health of fowls, and profit and loss.

1 2-hour laboratory period, credit 1.
Mr. Payne.

Prerequisite, Poultry 50.

55. **3.** INVESTIGATIONAL WORK.—For Juniors, Seniors may elect. This course is designed especially for students who are planning to do experiment station work. Students will be assigned specific problems to work out experimentally, or they may be required to assist in carrying on such work.

1 to 5 2-hour laboratory periods, credit 1-5.
Dr. Goodale.

75. **2.** POULTRY MANAGEMENT.—Seniors. A detailed study of large poultry farms and their equipment, such as bone cutters, feed cutters, cramming machines, etc.; the laying out and planning of poultry buildings of all kinds; mating of fowls. Attention to poultry diseases and investigation work carried on by experiment stations is prominent. A few good poultry plants will be visited by the class for practical demonstrations.

5 class hours. Credit 5.
Professor Graham.

Prerequisites, Poultry 53, 54, 76 and 77.

76. **1.** ADVANCED POULTRY JUDGING.—Seniors. This course includes a study of the origin and history of breeds and varieties, poultry organizations and poultry shows. The American Standard of Perfection will be used as a text.

2 class hours. 3 2-hour laboratory periods, credit 5.

Prerequisite, Poultry 53.

77. **1.** MARKET POULTRY AND POULTRY PRODUCTS.—Seniors. This course includes the study of market classifications of poultry, eggs and feathers, the requirements of different markets, methods of marketing, advantages and disadvantages of cold storage of poultry and eggs. Students will be required to fatten several lots of chickens by different methods and rations. Accurate data must be kept showing the gain in weight and quality, also the cost of feed, labor, etc., and the profit and loss. Judging and scoring of market poultry, both alive and dressed and market eggs will be an important feature of this course.

2 class hours. 3 2-hour laboratory periods, credit 5.
Mr. Payne.

Prerequisites, Poultry 50, 51 and 52.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

RURAL ENGINEERING.

Professor Gunness.

Elective Courses.

25. **1.** CARPENTRY.—For Sophomores, Juniors and Seniors may elect. Practice in the use of tools by exercises in bench work, repair of farm equipment and farm building construction.

2 2-hour laboratory periods, credit 2.
Rural Engineering Department.

26. **2.** REPAIR OF FARM EQUIPMENT.—For Sophomores, Juniors and Seniors may elect. Exercises in forge work, pipe fitting, soldering. Practice in the use of machinist's tools, such as file, cold chisel, drill press, taps and dies.

2 2-hour laboratory periods, credit 2.
Rural Engineering Department.

75. **1** FARM STRUCTURES.—For Seniors, Juniors may elect. Study of the strength, durability and cost of building materials; water supply; lighting and heating systems for the farm; drawing plans, writing specifications and estimating the cost of buildings; concrete construction as applied to foundations, silos, tanks, posts, floors and walks.

3 class hours. 2 2-hour laboratory periods, credit 5.
Professor Gunness.

76. **1.** FARM MECHANICS.—For Seniors, Juniors may elect. A general study of the farm equipment; farm buildings, their location, plan and arrangement; water supply; sewage disposal; lighting and heating systems; farm power and farm machinery. Course 76 has been planned for the benefit of those students who want a general course in farm mechanics but cannot spend the time to take the two courses 75 and 78.

3 class hours. 2 2-hour laboratory periods, credit 5.
Professor Gunness.

77. **2.** POWER MACHINERY.—For Seniors, Juniors may elect. Steam and gasoline engines, refrigerating machinery, electric motors and dynamos. Practice in pipe fitting, soldering, babbitting and fitting bearings, lacing belts and packing valves. Course 77 is intended primarily for dairy students, but would be valuable to any man who would expect to use engines, pumps or electrical machinery.

2 class hours. 3 2-hour laboratory periods, credit 5.
Professor Gunness.

78. **3.** FARM MACHINERY.—For Seniors, Juniors may elect. Study of the care and operation of tillage, seeding, harvesting, pumping and spraying machinery; steam and gas engines. Special attention will be given to the use of power on the small farm. Practice in the adjustment of the various machines, babbitting and fitting bearings, lining shafts and pulleys, lacing belts, splicing rope and packing valves.

2 class hours. 3 2-hour laboratory periods, credit 5.
Professor Gunness.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

DIVISION OF HORTICULTURE.

Professor WAUGH.

(The general subject of horticulture divides naturally into subjects of pomology, floriculture, forestry, landscape gardening and market gardening. A number of courses relate to more than one of these subjects, and are therefore grouped here under the general designation of horticulture.)

Elective Courses (*General*).

27. **3.** NURSERY PRACTICE.—For Sophomores, Juniors and Seniors may elect. This course treats of the fundamental methods of plant propagations by seeds, cuttings, budding, grafting, etc. Lectures and practicums.
2 class hours. 1 2-hour laboratory periods, credit 3.
Assistant Professor THOMPSON.

50. **1.** PLANT MATERIALS.—For Juniors, Seniors may elect. This course aims to make the student familiar with the character of the trees, shrubs and herbaceous perennials used in ornamental work and with the methods of propagating them.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor THOMPSON.

Prerequisite, Horticulture 27.

51. **3.** PLANT MATERIALS.—For Juniors, Seniors may elect. A continuation of Course 50, taking up the field use of trees, shrubs and herbaceous plants, their native habitats, soils and plant associations, with a view to supplying to students in landscape gardening and floriculture a knowledge of plant species. Frequent practicums and field excursions.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor THOMPSON.

Prerequisite, Horticulture 50.

75. **1.** PLANT BREEDING.—For Seniors and Graduate Students. (Not given in 1916-1917.) This course is designed to introduce advanced students to the best modern views of variation, heredity and evolution, and to the best methods of studying the phenomena found in these subjects. The principles educed apply to both animal breeding and plant breeding, but the laboratory work (of which there is considerable) is concerned chiefly with plant life. Some practice work in hybridization and selection is undertaken, and students are trained as far as possible in the practical application of those principles which have direct bearing on the breeding of plants and the cultivation of crops.
3 class hours. 2 2-hour laboratory periods, credit 5.
————————.

Prerequisite: Open only to students well prepared in agricultural or horticultural subjects.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

FLORICULTURE.

Associate Professor Nehrling, Mr. Thurston.

Elective Courses.

50. **1.** GREENHOUSE MANAGEMENT.—For Juniors, Seniors may elect. This course is designed to familiarize students with the methods followed in the management of greenhouse crops. The students are instructed in the practical operations of watering, potting, fumigating, ventilating and in the methods of propagation of plants by seed and cuttings. They will also be expected to arrange their hours according to the needs of the work.
2 class hours. 1 4-hour laboratory period, credit 4.
Associate Professor Nehrling and Mr. Thurston.

Prerequisite, Horticulture 27.

51. **2.** GREENHOUSE MANAGEMENT.—For Juniors, Seniors may elect. Continuation of Course 50. In addition, work in the use of cut flowers and plants in decorative work, the arrangement of flowers in baskets, designs, vases, table and home decorations will be considered.
2 class hours. 1 4-hour laboratory period, credit 4.
Associate Professor Nehrling and Mr. Thurston.

Prerequisite, Floriculture 50.

52. **3.** GREENHOUSE MANAGEMENT.—For Juniors, Seniors may elect. A continuation of Courses 50 and 51.
2 class hours. 1 4-hour laboratory period, credit 4.
Associate Professor Nehrling and Mr. Thurston.

Prerequisite, Floriculture 51.

53. **1.** GREENHOUSE CONSTRUCTION.—For Juniors, Seniors may elect. The location, arrangement, construction, cost, heating and ventilating of greenhouse structures; also the drawing of plans and drafting of specifications for commercial houses and private ranges. Such practical work as glazing, the construction of concrete benches and cold frames will be included in this course.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor Nehrling and Mr. Thurston.

Prerequisite: Should be taken with Floriculture 50.

75. **1.** COMMERCIAL FLORICULTURE.—Seniors. A detailed study will be made of the methods cultural for greenhouse plants and cut flowers for wholesale and retail markets. The care and marketing of all florists' crops will also be considered. Assigned readings on these topics.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor Nehrling.

Prerequisite, Floriculture 52.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

76. **3.** COMMERCIAL FLORICULTURE.—Seniors. As stated under Course 75.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor NEHRLING.
Prerequisite, Floriculture 75.

77. **2.** CONSERVATORY WORK AND DECORATIVE PLANTS.—Seniors. A study of the tropical and subtropical foliage and flowering plants used in conservatory work. Their arrangement and care will also be considered. Assigned readings.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor NEHRLING.
Prerequisite, Floriculture 75.

78. **3.** GARDEN FLOWERS AND BEDDING PLANTS.—Seniors. This course aims to make the student familiar with those annuals, herbaceous perennials, bulbs and bedding plants used in landscape work. Their propagation, culture and uses will be considered. Assigned readings and field trips.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor NEHRLING and MR. THURSTON.

79. **3.** SEMINAR.—For Seniors majoring in Floriculture, only. Advanced study of subjects pertaining to commercial floriculture or private garden work. All students electing this work will be assigned a specific problem and will pursue study in these problems by reading and research. No regular lectures will be given, but seminars will be conducted each week. A satisfactory report of the results must be presented.
2 to 6 laboratory hours, not to exceed 3 credits.
Associate Professor NEHRLING and MR. THURSTON.

FORESTRY.

Professor CLARK.

Elective Courses.

50. **1.** DENDROLOGY.—For Juniors, Seniors may elect. During the first part of the term frequent field trips will be made to identify and study the habits of our native forest trees. Later, the classification, range, distribution, forest habits, quality, uses and identification of wood of the commercial timber trees of the United States will be studied. Lectures, recitations, laboratories or field work at option of instructor.
3 2-hour laboratory periods, credit 3.
Professor CLARK.

51. **2.** WOOD TECHNOLOGY.—For Juniors, Seniors may elect. A study of the commercial woods found in the lumber markets, methods of identification, uses, strength values, technical qualities, decay and methods of preservation.
1 class hour. 2 2-hour laboratory periods, credit 3.
Professor CLARK.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

52. **3.** PRINCIPLES OF FORESTRY.—For Juniors, Seniors may elect. A lecture course for the purpose of giving the students a general view of the whole field of forestry and what forestry attempts to accomplish and has accomplished. Not required of students who propose to major in forestry.
2 class hours. Credit 2.
Professor CLARK.

53. **3.** SILVICULTURE.—For Juniors, Seniors may elect. Factors influencing forest growth; forest types; silvicultural systems; care and protection of forests; forest description; forest nursery practice and forest planting.
1 class hour. 1 4-hour laboratory period, credit 3.
Professor CLARK.
Prerequisite, Forestry 50.

75. **1.** FOREST MENSURATION.—For Seniors, Juniors may elect. Methods of determining the volume of trees, logs and entire forests. Methods of computing volume tables, tree and forest growth and yield tables. Timber estimating.
3 class hours. 72 hours field work, credit 5.
Professor CLARK.

78. **3.** SEMINAR.—REPORT.—Seniors. This may involve research, laboratory or field work in the investigation of some subject, together with a review of the literature relating to it and an original written report evidencing the results. Subject to be chosen in conference with Professor Clark.
6 laboratory hours, credit 3.
Professor CLARK.

LANDSCAPE GARDENING.

Professor WAUGH, Assistant Professor HARRISON.

Elective Courses.

50. **1.** ELEMENTS OF LANDSCAPE GARDENING.—Juniors. Reconnoissance surveys and mapping, with special reference to the methods used in landscape gardening; detailed study of selected designs of leading landscape gardeners; grade design, road design and field work. Must be followed by Course 51.
2 2-hour laboratory periods,
2 3-hour laboratory periods, credit 5.
Professor WAUGH.
Prerequisites, Mathematics 25 and 26, Drawing 25, 26 and 27, Horticulture 27.

51. **2.** ELEMENTS OF LANDSCAPE GARDENING.—Juniors. As stated under Course 50.
3 3-hour laboratory periods, credit 4.
Assistant Professor HARRISON.
Prerequisite, Landscape Gardening 50.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

52. **3.** GENERAL DESIGN.—Juniors. Field notes; examination of completed works and those under construction; design of architectural details, planting plans, gardens, parks and private grounds; written reports on individual problems. Must be followed by Course 53.

2 2-hour laboratory periods,
2 3-hour laboratory periods, credit 5.
Assistant Professor Harrison.

Prerequisites, Landscape Gardening 50 and 51, and either plant materials (Horticulture 50 and 51) or advanced mathematics.

53. **4.** (Summer). GENERAL DESIGN.—Juniors. As stated under Course 52.

120 laboratory hours, credit 5.
Assistant Professor Harrison.

Prerequisite, Landscape Gardening 52.

75. **1.** THEORY OF LANDSCAPE ART.—For Seniors and Graduates. The general theory and applications of landscape study, including a brief history of the art.

3 class hours. Credit 3.
Professor Waugh.

76. **2.** CIVIC ART.—Seniors. The principles and applications of modern civic art, including city planning, city improvement, village improvement and rural improvement with special emphasis upon country planning. Must be followed by Course 77.

3 3-hour laboratory periods, credit 4.
Professor Waugh.

Prerequisite, Landscape Gardening 53.

77. **3.** CIVIC ART.—Seniors. As stated under Course 76.

3 3-hour laboratory periods, credit 4.
Professor Waugh.

Prerequisite, Landscape Gardening 76.

78. **3.** ARCHITECTURE.—Alternating with Course 79; given in 1916-1917. Juniors and Seniors. The history of architectural development, the different historic types, with special reference to the underlying principles of construction and design and their relations to landscape design. Illustrated lectures, conferences, practice in designing.

3 class hours. Credit 3.
Assistant Professor Harrison.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

79. **3.** CONSTRUCTION AND MAINTENANCE.—Alternating with Course 78; given in 1917-18. Juniors and Seniors. Detailed instruction in methods of construction and planting in carrying out plans, in organization, reporting, accounting, estimating, etc.; maintenance work in parks and on estates, its organization, management, cost, etc.
3 class hours. Credit 3.
Assistant Professor HARRISON.

MARKET GARDENING.

Professor TOMPSON, Assistant Professor TOMSON.

Elective Courses.

50. **3.** ELEMENTS OF MARKET GARDENING. Juniors, Seniors may elect. A study of the business of commercial vegetable growing to acquaint the student with the fundamental considerations of the business and a knowledge of the market garden crops. The study of the crops will consist of classroom, laboratory and field work dealing with propagation, cultivation and marketing. Text and reference books.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor TOMSON.

75. **1.** ELEMENTS OF MARKET GARDENING.—Seniors. A continuation of Market Gardening 50. A systematic study of types, varieties and strains of the leading vegetable crops, as well as a study of the problems of farm planning, irrigation, crop rotation, spraying, storage and methods of marketing and seed production. Text and reference books. Occasional seminars. Laboratory and field work.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor TOMSON.

Prerequisite, Market Gardening 50.

76. **2.** GREENHOUSE VEGETABLE GROWING.—Seniors. A study of the production of vegetables under glass as a business, briefly considering economic reasons for its development, progress, in methods, and management, and the present status of the industry. A study of vegetable forcing house construction, heating and greenhouse management, as applied to the leading greenhouse crops, lettuce, cucumbers and tomatoes with proportionate time given to the crops of lesser importance. Text and reference books and periodicals. Greenhouse work in actual production and management is a part of this course and the student must so arrange that he can give it adequate attention. Considerable Seminar work.
3 class hours. 2 2-hour laboratory periods, credit 5.
Assistant Professor TOMSON.

Prerequisite, Market Gardening 75.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:
1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

POMOLOGY.

Professor SEARS, Associate Professor CHENOWETH.

Elective Courses.

1. **1 and 2.** POMOLOGY.—Freshman. Given as part of the Freshman Agriculture and Horticulture. This course is designed to give the students a general introduction to Horticulture. It consists principally of laboratory work, such as judging fruits, vegetables, etc., both in the class room and in the orchard or field. Six weeks, part of class only, 1st Term; balance of class six weeks during the 2nd Term.

2 2-hour laboratory periods, credit 1.
POMOLOGY DEPARTMENT.

50. **1.** PRACTICAL POMOLOGY.—For Juniors, Seniors may elect. A study of the general principles of the growing of fruits, dealing with such questions as selection of site, soils, windbreaks, laying out plantations, choice of nursery stock, pruning, culture of orchards, orchard fertilizers, cropping orchards, etc. Text and reference books; field and laboratory exercises.

2 class hours. 1 2-hour laboratory periods, credit 3.
Professor SEARS.

Prerequisite, Horticulture 27.

51. **2.** PRACTICAL POMOLOGY.—For Juniors, Seniors may elect. As stated under Course 50.

2 class hours. 1 2-hour laboratory period, credit 3.
Professor SEARS.

Prerequisite, Pomology 50.

52. **3.** PRACTICAL POMOLOGY.—For Juniors, Seniors may elect. As stated under Course 50.

2 class hours. 1 2-hour laboratory period, credit 3.
Professor SEARS.

Prerequisite, Pomology 51.

53. **4.** (Summer). SMALL FRUITS. For Juniors, Seniors may elect. The growing, harvesting, marketing, and storing of small fruits, including currants, gooseberries, and grapes, together with thinning, spraying, picking and marketing of tree fruits at the college orchards and in private commercial orchards.

120 laboratory hours, credit 5.
Associate Professor CHENOWETH.

75. **1.** SYSTEMATIC POMOLOGY.—Seniors. A study of the varieties of the different fruits and of nomenclature, with critical descriptions; special reference being given to relationships and classification. Text books, laboratory and field exercises.

1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor CHENOWETH.

Prerequisite, Pomology 52.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

76. **2.** SYSTEMATIC POMOLOGY.—Seniors. As stated under Course 75.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor CHENOWETH.

Prerequisite, Pomology 75.

77. **1.** COMMERCIAL POMOLOGY.—Seniors only, majoring in Pomology. The picking, handling, storing and marketing of fruits, including a discussion of storage houses, fruit packages, methods of grading and packing, manufacturing, etc. Especial emphasis is placed upon laboratory and field work, where the student is given actual practice in the picking and packing of all the principal fruits, together with the manufacture of by-products.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor CHENOWETH.

Prerequisite, Pomology 52.

78. **3.** SPRAYING.—Seniors. A study of (a) spraying materials, their composition, manufacture and preparation for use; the desirable and objectionable qualities of each material, formulas used, cost, tests of purity. (b) Spraying machinery, including all the principal types of pumps, nozzles, hose and vehicles; their structure and care. (c) Orchard methods in the application of the various materials used, with the important considerations for spraying each fruit and for combating each orchard pest. This course is designed especially to familiarize the student with the practical details of actual spraying work in the orchard. Spray materials are prepared, spraying apparatus is examined and tested, old pumps are overhauled and repaired, and the actual spraying is done in the college orchards and small fruit plantations.
1 class hour. 2 2-hour laboratory periods, credit 3.
Professor SEARS.

Prerequisite, Pomology 52.

DRAWING.

MR. ROOT.

Elective Courses.

25. **1.** FREE-HAND DRAWING.—For Sophomores, Juniors and Seniors may elect. Lettering; free-hand perspective; sketching from type models, leaves, flowers and trees, houses, etc.; laying flat and graded washes in water colors; water color rendering of leaves, flowers and trees; conventional coloring and map rendering in water colors; conventional signs and mapping in ink.
3 2-hour laboratory periods, credit 3.
MR. ROOT.

26. **2.** MECHANICAL DRAWING.—For Sophomores, Juniors and Seniors may elect. Inking exercises; geometric problems; projection; intersections, isometric; shades and shadows; parallel; angular and oblique perspective; perspective drawing of buildings. Students should have preparation in plane and solid geometry.
3 2-hour laboratory periods, credit 3.
MR. ROOT.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

27. **3.** MECHANICAL DRAWING.—For Sophomores, Juniors and Seniors may elect. As stated under Course 26.

3 2-hour laboratory periods, credit 3.
Mr. Root.

Prerequisite, Drawing 26.

BOTANY.

Professor Osmun, Associate Professor Anderson, Assistant Professor Clark, Mr. McLaughlin, Mr. Martin, Mr. Doran.

Required Courses.

3. **3.** MORPHOLOGY AND TAXONOMY OF THE HIGHER PLANTS (PHANEROGAMIA).—Freshmen. Seeds and seedlings; types of leaves, stems, roots and flowers. Determination and naming of plants using Gray's "New Manual of Botany." An herbarium of 75 species of plants is required of each student.

1 class hour. 2 2-hour laboratory periods, credit 3.
Professor Osmun, Mr. McLaughlin, Mr. Martin, Mr. Doran.

25. **1.** ANATOMY, PHYSIOLOGY AND ECOLOGY OF THE HIGHER PLANTS.—Sophomores. Structure, functions, metabolism and environmental relations of seed plants.

1 class hour. 2 2-hour laboratory periods, credit 3.
Professor Osmun, Mr. McLaughlin, Mr. Martin, Mr. Doran.

Prerequisite, Botany 3.

Elective Courses.

26. **2.** MORPHOLOGY AND TAXONOMY OF THE LOWER PLANTS (CRYTOGAMIA).—Sophomores. Systematic study of typical forms of bacteria, algae, fungi, lichens, mosses, ferns. (Courses 3, 25, and 26 constitute a general elementary course in botany, and are prerequisites of all subsequent work taken in the Department of Botany.)

1 class hour. 2 2-hour laboratory periods, credit 3.
Professor Osmun, Mr. McLaughlin, Mr. Martin, Mr. Doran.

Prerequisite, Botany 25.

50. **1.** DISEASES OF CROPS.—For Juniors, Seniors may elect. Laboratory and recitations devoted to diseases of the special crops related to the student's major. Arranged in sections for students specializing in (1) agronomy or market gardening; (2) floriculture or landscape gardening; (3) forestry or pomology; (4) entomology. Students may take the laboratory work in one, two or three sections. The laboratory work for students in entomology is general and includes the more important diseases studied in the other sections. The class is not sectioned for lectures, which are general.

1 class hour. 1, 2 or 3 2-hour laboratory periods, credits 2, 3 or 4.
Associate Professor Anderson, Mr. McLaughlin.

Prerequisite, Botany 26.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

51. **2.** DISEASES OF CROPS.—For Juniors, Seniors may elect. As stated under Course 50.
1 class hour. 1, 2 or 3 2-hour laboratory periods, credits 2, 3 or 4
Associate Professor ANDERSON, MR. MCLAUGHLIN.

Prerequisite, Botany 50.

52. **1.** SYSTEMATIC MYCOLOGY.—For Juniors, Seniors may elect. Morphology and development of typical species representing the orders and families of fungi; practice in identification, collection and preservation of fungi; study of systems of classification; collateral reading. A prerequisite of the senior course in plant pathology, but open to all.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor ANDERSON.

Prerequisite, Botany 26.

53. **2.** SYSTEMATIC MYCOLOGY.—For Juniors, Seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor ANDERSON.

Prerequisite, Botany 52.

54. **3.** SYSTEMATIC MYCOLOGY.—For Juniors, Seniors may elect. As stated under Course 52.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor ANDERSON.

Prerequisite, Botany 53.

55. **1.** PLANT HISTOLOGY.—For Juniors, Seniors may elect. Comparative study of the tissues of plants; training in histological methods, including the use of precision microtomes, methods of killing, fixing, sectioning, staining and mounting; collateral reading and conferences. This course offers valuable training in preparation for further work in botany.
1 class hour. 2 2-hour laboratory periods, credit 3.
Professor OSMUN.

Prerequisite, Botany 26.

56. **2.** PLANT HISTOLOGY.—For Juniors, Seniors may elect. As stated under Course 55.
1 class hour. 2 2-hour laboratory periods, credit 3.
Professor OSMUN.

Prerequisite, Botany 55.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

75. **1.** PLANT PATHOLOGY.—Seniors. Comprehensive study of diseases of plants; training in laboratory methods and technique, including culture work and artificial inoculation of hosts; miscellaneous diagnosis; study of literature and representative life-histories of pathogens. Prepares for civil service, experiment station and college work.
1 class hour. 4 2-hour laboratory periods, credit 5.
Professor Osmun and Associate Professor Anderson.

Prerequisite, Botany 54.

76. **2.** PLANT PATHOLOGY.—Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit 5.
Professor Osmun and Associate Professor Anderson.

Prerequisite, Botany 75.

77. **3.** PLANT PATHOLOGY.—Seniors. As stated under Course 75.
1 class hour. 4 2-hour laboratory periods, credit 5.
Professor Osmun and Associate Professor Anderson.

Prerequisite, Botany 76.

78. **1.** PLANT PHYSIOLOGY.—Seniors. A general course dealing with such topics as absorption, nutrition, growth, and movements of plants; training in laboratory methods and the use of apparatus; collateral reading.
2 class hours. 3 2-hour laboratory periods, credit 5.
Assistant Professor Clark.

Prerequisites, Botany 26 and Chemistry 51.

79. **2.** PLANT PHYSIOLOGY.—Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit 5.
Assistant Professor Clark.

Prerequisite, Botany 78.

80. **3.** PLANT PHYSIOLOGY.—Seniors. As stated under Course 78.
2 class hours. 3 2-hour laboratory periods, credit 5.
Assistant Professor Clark.

Prerequisite, Botany 79.

82. **2.** CYTOLOGY AND EMBRYOLOGY.—Seniors. Morphology and physiology of the cell; cell-division; embryonal development.
1 class hour. 2 2-hour laboratory periods, credit 3.
Assistant Professor Clark.

Prerequisites, Botany 26 and 55.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

83. **3.** CYTOLOGY AND EMBRYOLOGY.—Seniors. As stated under Course 82.
1 class hour. 2 2-hour laboratory periods, credit 3.
Assistant Professor Clark.
Prerequisite, Botany 82.

84. **2.** SHADE TREE MANAGEMENT.—Seniors. Not offered in 1916-17.

85. **3.** SHADE TREE MANAGEMENT.—Seniors. Not offered in 1916-17.

86. **1.** SEMINAR.—For Seniors and Graduate Students. Presentation and discussion of important current botanical papers. A major requirement.
1 class hour or 2 laboratory hours. Credit 1.
The Department.

87. **2.** SEMINAR.—For Seniors and Graduate Students. As stated under Course 86.
1 class hour or 2 laboratory hours. Credit 1.
The Department.

88. **3.** SEMINAR.—For Seniors and Graduate Students. As stated under Course 86.
1 class hour or 2 laboratory hours. Credit 1.
The Department.

GENERAL AND AGRICULTURAL CHEMISTRY.

Professor Lindsey, Professor Wellington, Professor Chamberlain, Associate Professor Peters, Associate Professor Anderson, Mr. Serex, Mr. Erichsen, Mr. MacNeil, Mr. Perry, Mr. Phillips.

[The course in chemistry aims to teach accurate observation, logical thinking and systematic and constant industry. It likewise aims to give those students following the several agricultural occupations, or who are preparing themselves for work as teachers and investigators in the other sciences, a knowledge of the subject sufficient to enable them to apply it in their various lines of work. Students taking all of the undergraduate courses and intending to follow chemistry as a vocation are prepared for positions as instructors in high schools and colleges in the agricultural experiment stations, the United States Department of Agriculture, as well as in fertilizer cattle food, sugar and dairy industries. Students are encouraged to take especially graduate work leading to the degree of M.Sc., and to thus prepare themselves for advanced positions as teachers in the agricultural colleges, as research chemists, and likewise for the more responsible positions connected with the different agricultural industries of the country. A fuller knowledge of the course of instruction will be found by consulting the following outline.]

Required Courses.

1. **1.** GENERAL CHEMISTRY.—Freshmen. An introduction to the fundamental chemical laws, together with a study of the common acid-forming elements and their compounds. Text-book, Kahlenberg's "Outlines of Chemis-

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

try." This course is for those students who do not present chemistry for entrance, and who begin the subject in college.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor PETERS, MR. SEREX, MR. ERICHSEN and MR. PERRY.

2. **2.** GENERAL CHEMISTRY.—Freshmen. A continuation of Course 1. A study of metals and their compounds. The laboratory work is the same as described under Course 4.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor PETERS and Assistants.

3. **3.** GENERAL CHEMISTRY.—Freshmen. As stated under Courses 1 and 2.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor PETERS and Assistants.

4. **1.** ADVANCED GENERAL CHEMISTRY.—Freshmen. A review of the fundamental chemical laws, together with the common acid and base-forming elements and their compounds. Text-book, Kahlenberg's "Outlines of Chemistry." The laboratory work takes the synthetic form. Substances of agricultural importance are prepared in quantity and studied in detail by the student. These include ammonium sulfate, superphosphate, muriate and sulfate of potash, arsenate of lead, Paris green, Bordeaux mixture, lime-sulfur and emulsions. In addition to these, preparations outlined in Blanchard's "Synthetic Inorganic Chemistry" are made.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor ANDERSON, MR. SEREX, MR. ERICHSEN, and MR. PHILLIPS.
Prerequisite, Presentation of Chemistry for entrance.

5. **2.** INORGANIC AGRICULTURAL CHEMISTRY.—Freshmen. A study of the chemical composition, properties and reactions of soils, fertilizers, fungicides and insecticides, and the common materials of construction, such as tile, brick, cements, paints, etc. Text-book, Fraps' "Principles of Agricultural Chemistry." The laboratory work is divided into three parts, as follows: (a) qualitative examination of soil, plant ash and superphosphate; (b) approximate quantitative determination of moisture, ash, carbonic acid, phosphoric acid, potash, etc.; (c) special work on retention of salts by soil, leaching of lime from the soil by carbonated water, etc.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor ANDERSON and Assistants.
Prerequisite, Chemistry 3 or 4.

6. **3.** ORGANIC AGRICULTURAL CHEMISTRY.—Freshmen. As stated in Course 30.
2 class hours. 1 2-hour laboratory period, credit 3.
Professor CHAMBERLAIN and Assistants.
Prerequisites, Chemistry 4 and 5.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24	inclusive	Freshmen	50 to 74	inclusive	Juniors
25 to 49	"	Sophomores	75 to 99	"	Seniors

Elective Courses.

25. **1.** QUALITATIVE ANALYSIS.—*Basic.*—Sophomores. A course in the systematic analysis of metallic salts, presented from the ionic viewpoint. The student studies closely the tests used in the separation and identification of the metals; he then applies these tests to unknown mixtures. Text, Medicus' ''Qualitative Analysis,'' with Böttger's ''Qualitative Analysis'' and Treadwell-Hall's ''Qualitative Analysis'' for reference. This Course should be taken, particularly, by all intending to follow chemistry as a vocation.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor ANDERSON and MR. PHILLIPS.

Prerequisite, Chemistry 3 or 6.

26. **2.** QUALITATIVE ANALYSIS.—*Acidic.*—Sophomores. A continuation of Course 25. A large part of the term is spent in the examination qualitatively of minerals and of agricultural products.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor ANDERSON and MR. PHILLIPS.

Prerequisite, Chemistry 25.

27. **3.** QUANTITATIVE ANALYSIS.—For Sophomores, Juniors and Seniors may elect. Instruction in this course includes the gravimetric and volumetric determinations of some of the commoner metals and non-metals in minerals and industrial products. Aside from teaching accurate observation and care in manipulation, it is intended for those who would learn the exact methods for determining the elements, particularly, in inorganic substances, and is the forerunner of other courses intended to fit men to become expert analysts. Talbot's ''Quantitative Chemical Analysis'' is used as a text.
1 class hour. 2 4-hour laboratory periods, credit 5.
Professor WELLINGTON, Associate Professor PETERS and MR. MACNEIL.

Prerequisite, Chemistry 25. Course 26 is prerequisite for those majoring in Chemistry.

30. **3.** ORGANIC AGRICULTURAL CHEMISTRY.—For Sophomores, Juniors and Seniors may elect. The course embraces the study of the most important groups of organic compounds of plants and animals, the composition of plants, the chemistry of plant growth, plants as food and as industrial material, the composition of animals, the chemistry of digestion, also the study of some of the products related to plants and animals, such as milk, butter, cheese, sugar, alcohol, wood pulp and paper. The treatment of the subject will be general, avoiding (so far as possible) complicated chemical facts and relationships, and endeavoring simply to make the student acquainted with the general chemistry of plants and animals and agricultural processes and products.
3 class hours. 2 2-hour laboratory periods, credit 5.
Professor CHAMBERLAIN and MR. PERRY.

Prerequisite, Chemistry 3 or 6.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

51. **1.** ORGANIC CHEMISTRY.—For Juniors, Seniors may elect. This course is designed especially: (1) for those who are looking forward to positions as chemists in agricultural colleges or experiment stations, the United States Department of Agriculture, or similar places, and who need a knowledge of chemistry for itself; and (2) for those who are expecting to enter like positions in other sciences, and who will use their knowledge of chemistry in a secondary way. It consists of a systematic study, both from texts and in the laboratory, of the more important compounds in the entire field of organic chemistry. Especial attention is given to those compounds which are found in agricultural products or are manufactured from them. These include alcohols, acids, esters, fats, carbohydrates, proteins, etc. The work forms a foundation for courses in physiological chemistry and agricultural analysis, and thus for future work in agricultural chemical investigation. Those electing Course 51 are expected to elect Course 52.
5 class hours. 2 3-hour laboratory periods, credit 8.
Professor CHAMBERLAIN and MR. PERRY.

Prerequisites, Chemistry 3 or 6, and Chemistry 27 for those majoring in Chemistry.

52. **2.** ORGANIC CHEMISTRY.—For Juniors, Seniors may elect. As stated under Course 51.
5 class hours. 2 3-hour laboratory periods, credit 8.

Prerequisite, Chemistry 51.

60. **1.** ADVANCED QUANTITATIVE CHEMISTRY.—For Juniors, Seniors may elect. Advanced work on subjects as stated under Course 27.
1 class hour. 1 4-hour laboratory period, credit 3.
Professor WELLINGTON, Associate Professor PETERS and Assistants.

Prerequisite, Chemistry 27.

61. **2.** INSECTICIDE ANALYSIS.—For Juniors, Seniors may elect. A study of methods for the analysis of Insecticides.
1 class hour. 1 4-hour laboratory period, credit 3.
Professor WELLINGTON, Associate Professor PETERS and Assistants.

Prerequisite, Chemistry 27.

62. **3.** SOILS AND FERTILIZER ANALYSES.—For Juniors, Seniors may elect. A study of methods for analyses of soils and fertilizers.
1 class hour. 2 4-hour laboratory periods, credit 5.
Professor WELLINGTON, Associate Professor PETERS and Assistants.

Prerequisite, Chemistry 27.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

65. **3.** PHYSICAL CHEMISTRY.—For Juniors, Seniors may elect. A résumé of general chemistry from the viewpoint of physical chemistry and the application of physical chemistry to agricultural chemistry.
3 class hours. 2 2-hour laboratory periods, credit 5.
Associate Professor ANDERSON and MR. PHILLIPS.
Prerequisite, Chemistry 27.

76. **1.** MILK AND BUTTER ANALYSIS.—For Seniors, Juniors may elect. A study of chemical methods of analysis of milk and butter.
1 class hour. 2 4-hour laboratory periods, credit 5.
Professor PETERS and Assistants.
Prerequisite, Chemistry 27.

77. **2.** CATTLE FEED AND WATER ANALYSIS.—For Seniors, Juniors may elect. A study of methods of analysis of cattle feeds and water.
1 class hour. 1 4-hour laboratory period, credit 3.
Professor PETERS and Assistants.
Prerequisite, Chemistry 27.

80. **1.** PHYSIOLOGICAL CHEMISTRY.—Seniors. This course is intended to be supplementary to Courses 51 and 52, and Course 30. To those who expect to take up scientific work in microbiology, botany, agronomy, animal husbandry, etc., and who have had Courses 51 and 52, it will give acquaintance with the chemistry of the physiological processes in plants and animals, by means of which some of the important organic compounds studied in Courses 51 and 52 are built up in the living organism or are used as food by it. In the lectures the study of food and nutrition as related to both human and domestic animals is the principal subject. In the laboratory, experimental studies are made of the animal body and the processes and products of digestion, secretion and excretion. The course gives additional training in the chemical problems of agricultural experiment-station work, especially those connected with investigations in animal and plant nutrition. To those who will not take up scientific lines of work, but will follow practical agriculture, it will give an opportunity for a more detailed study of the chemistry and physiology of problems, which were treated generally in Course 30.
3 class hours. 2 2-hour laboratory periods, credit 5.
Professor CHAMBERLAIN and MR. PERRY.
Prerequisites, Preferably Chemistry 30 or 51 and 52.

87. **3.** HISTORY OF CHEMISTRY.—Seniors. An exposition of the development of chemical knowledge from the earliest times to the present. Although the entire history will be included, the larger portion of it will receive only brief mention in order that the questions of vital interest in modern life and industry may be studied at greater length. Particular attention will be given to the questions of plant and animal industry. Chemists are strongly advised to take this course.
3 class hours. Credit 3.
Professor WELLINGTON.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

90. **2.** SPECIAL WORK IN AGRICULTURAL CHEMICAL ANALYSIS.—Seniors. The student is given a problem to solve either in analytical chemistry or related to the agricultural industries. This is to acquaint him with the methods used in research and with the literature, and show him how to handle problems in this field of chemistry when occasion arises.

6 laboratory hours, credit 3.
Associate Professor PETERS.

91. **3.** SPECIAL WORK IN AGRICULTURAL CHEMICAL ANALYSIS.—Seniors. As stated in Course 90.

10 laboratory hours, credit 5.
Associate Professor PETERS.

Prerequisite, Chemistry 90.

92. **2.** SPECIAL WORK IN PHYSIOLOGICAL AND ORGANIC AGRICULTURAL CHEMISTRY.—Seniors. In this course, as in Courses 90 to 94, the student will be able to give his attention primarily to one line of chemical study. To those whose tastes and interests are in connection with the organic and physiological problems of agricultural chemistry, many subjects of study present themselves, among which may be mentioned: proteins, carbohydrates, fats, organic nitrogenous compounds in fertilizers and soils and their relation to plants, the commercial production of alcohol from agricultural products, digestion and dietary studies, the chemical study of dairy products, etc.

6 laboratory hours, credit 3.
Professor CHAMBERLAIN.

Prerequisites, Chemistry 51, 52 and 80.

93. **3.** SPECIAL WORK IN PHYSIOLOGICAL AND ORGANIC AGRICULTURAL CHEMISTRY.—Seniors. As stated under Course 92.

10 laboratory hours, credit 5.
Professor CHAMBERLAIN.

Prerequisite, Chemistry 92.

94. **3.** SPECIAL WORK IN PHYSICAL CHEMISTRY.—Seniors. The field of agricultural chemistry offers many problems that have been attacked through the methods of physical chemistry; such, for example, are the hydrolysis of salts and of minerals and the absorption of salts and fertilizers by soils. Each student will select one line of work and follow it through the course, repeating some of the original work.

6 laboratory hours, credit 3.
Associate Professor ANDERSON.

Prerequisite, Chemistry 65.

95. **3.** SPECIAL WORK IN PHYSICAL CHEMISTRY.—Seniors. As stated under Course 94.

10 laboratory hours, credit 5.
Associate Professor ANDERSON.

Prerequisite, Chemistry 94.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

ENTOMOLOGY.

Professor Fernald, Professor Crampton, Associate Professor Gates, Dr. Regan.

Elective Courses.

26. **2.** GENERAL AND ECONOMIC ENTOMOLOGY.—For Sophomores, Juniors and Seniors may elect. Course 26 comprises a general introduction to the study of insects, including studies on their structure as applied to their identification; the principles of classification; a systematic examination of the different groups and of the most important economic insects of each group, including their life histories and habits, recognition of their work as shown in the collections, and methods for their control. The most important insecticides and their preparation and application are also treated. Students electing Course 26 are expected to take Course 27.
3 class hours. Credit 3.
Professor Fernald.

27. **3.** GENERAL AND ECONOMIC ENTOMOLOGY.—For Sophomores, Juniors and Seniors may elect. A continuation of Course 26 with laboratory and field work on methods of collecting, preserving and studying insects and their work.
2 2-hour laboratory periods, credit 2.
Professor Fernald.

Prerequisite, Entomology 26.

60. **3.** BEEKEEPING.—For Juniors, Seniors may elect. This course comprises a general consideration of the biology of the honeybee and the elements of practical beekeeping. Some topics covered are: life history, general behavior and instincts, structure, products, relations of bees to plants, the honey flora. The course aims particularly to afford firsthand, practical experience with bees, to the end of enabling their proper maintenance for any purpose, horticultural, educational or apicultural. Bee diseases, a thorough understanding of which is fundamental, are emphasized. So far as possible the work is made individual in constructing materials and apparatus and in the manipulation of bees.
3 class hours. 2 2-hour laboratory periods, credit 5.
Associate Professor Gates.

Prerequisites, Entomology 26 and 27 desirable.

75. **3.** FOREST AND SHADE-TREE INSECTS.—Seniors. A study of the insects injurious to forest and shade-trees, and of methods for their control, with laboratory and field work on these insects, and a study of what has been published about them.
1 class hour. 3 2-hour laboratory periods, credit 4.
Professor Fernald.

Prerequisites, Entomology 26 and 27.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

76. **1.** ADVANCED ENTOMOLOGY.—Seniors. This course is subdivided, the time spent on the various subdivisions differing somewhat according to the particular needs of those taking it; and it is to a large degree given in the form of individual instruction, special attention being paid to the pests attacking the particular crops in which the student is most interested. The student may specialize in fruit pests, market-garden pests, greenhouse pests, field crop pests, etc., to a large extent, in accordance with his plans for future work.

A. *Morphology.*—Careful studies of the structure of insects belonging to each of the large and more important orders, together with lectures on the subject, followed by the identification of insects of each of these groups and the study of the collections, to teach the use of the analytical tables and of structural characters in the determination of insects.

B. *Histology.*—Lectures on the internal anatomy and histology of the various organs, with particular reference to those affected by the various insecticides.

C. *Insecticides and Apparatus.*—Lectures on the chemistry, preparation and application of the different insecticides, their merits and defects; tests for detecting adulterations; comparative tests of nozzles and other apparatus; and a study of other methods of insect control, together with laboratory work.

D. *Coccidology.*—Lectures and laboratory work on methods of preserving. mounting and identifying scale insects, particular attention being given to those of greatest economic importance.

E. *Bibliography.*—Studies of the various entomological publications and of the methods of finding the literature on any insect.

F. *Special Studies.*—In these studies the insects most closely related to the future occupation of the student will receive attention. The results of these studies are brought together in the form of an essay or thesis; this will include all the essentials of what is known of the life history, habits and injuries caused by each insect studied, together with methods of treatment, and a list of the best articles found in the course of the work. Comstock's ''Manual for the Study of Insects" is used in the laboratory work.
2 class hours. 3 2-hour laboratory periods, credit 5.
Professor FERNALD and Professor CRAMPTON.

Prerequisites, Entomology 26 and 27.

77. **2.** ADVANCED ENTOMOLOGY.—Seniors. As stated in Course 76.
3 2-hour laboratory periods, credit 3.
Professor FERNALD and Professor CRAMPTON.

Prerequisite, Entomology 76.

78. **3.** ADVANCED ENTOMOLOGY.—Seniors. As stated under 76.
1 class hour. 3 2-hour laboratory periods, credit 4.
Professor FERNALD and Professor CRAMPTON.

Prerequisite, Entomology 77.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

80. **3.** ADVANCED BEEKEEPING.—For Seniors, Juniors may elect. This course deals with the advanced and special problems of the beekeeper. Besides considering those difficulties which at present confront the industry, subjects necessarily of limited treatment in the previous course are expanded for the development of particular technique and manipulation. Apiary management, including the principles of queen rearing, are practiced. The course should further qualify for apicultural instruction and inspection service, affording familiarity with the special literature and methods needed in investigation and research. The policy of individual instruction is continued in so far as practicable.
2 class hours. 1 2-hour laboratory period, credit 3.
Associate Professor Gates.
Prerequisite, Entomology 60.

90. **2.** EVOLUTION.—For Seniors, Juniors may elect. In order to demonstrate the universal scope and operation of the laws of evolution, the course includes a brief sketch of the probable origin and evolution of matter as viewed in the light of modern physical and chemical research; the evolution of the solar system, leading to the formation of the earth; the changes in the earth, preparatory to the production of life; the physical and chemical basis of life; the probable steps in the formation of living matter, and the theories concerning it; the evolution of living things; the appearance of man; his future in the light of his past development; and the evolution of human institutions and ideas. Consideration is also given to the theories concerning the factors of evolution, the general problems of heredity and similar topics. The course closes with a brief discussion of the philosophical, moral and social aspects of the problems involved, and the influence of the idea of evolution upon modern thought. The lectures are supplemented by collateral reading; and a portion of the time is used for the purpose of demonstration, or discussion by the class.
3 class hours. Credit 3.
Professor Crampton.

MATHEMATICS AND CIVIL ENGINEERING.

Professor Ostrander, Assistant Professor Duncan, Assistant Professor Machmer, Mr. Hazeltine.

Required Courses.

1. **1.** HIGHER ALGEBRA.—Freshmen. A brief review of radicals, quadratic equations, ratio and proportion, and progressions; graphs, binomial theorem, undetermined coefficients, summation of series, variation, continued fractions, determinants, permutations and combinations, logarithms, theory of equations. Reitz and Crathorne's "College Algebra."
5 class hours. Credit 5.
Assistant Professor Duncan, Assistant Professor Machmer and Mr. Hazeltine.

2. **2.** HIGHER ALGEBRA.—As stated under Course 1.
2 class hours. Credit 2.
Assistant Professor Duncan, Assistant Professor Machmer and Mr. Hazeltine.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

3. **3.** SOLID GEOMETRY.—Freshmen. Theorems and exercises on the properties of straight lines and planes, dihedral and polyhedral angles, prisms, pyramids and regular solids; cylinders, cones and spheres; spherical triangles and the measurement of surfaces and solids. Wentworth and Smith's "Solid Geometry." Required unless accepted for admission.
3 class hours. Credit 3.

Assistant Professor Duncan, Assistant Professor Machmer and Mr. Hazeltine.

5. **2.** PLANE TRIGONOMETRY, (in charge of Department of Physics).—Freshmen. The trigonometric functions as lines and ratios; proofs of the principal formulas, transformations; inverse functions, use of logarithms; the applications to the solution of right and oblique triangles; practical applications. Bowser's "Elements of Plane and Spherical Trigonometry."
3 class hours. Credit 3.

Professor Hasbrouck and Assistant Professor Robbins.

6. **3.** MENSURATION AND COMPUTATION.—Freshmen. The course includes a review of methods of computation, with special emphasis on short and abbreviated processes, together with methods of checking computations and of forming close approximations; use of slide rule. Also the graph, mensuration of plane and solid figures, weights and measures and elementary mechanism. Numerous practical problems are selected from such subjects as the following: the mathematics of woodworking; rough lumber; general construction; forestry methods in heights of trees; pulleys, belts and speeds; power and its transmission; dairying; agronomy; computation of areas from simple measurements.
2 class hours. Credit 2.

Assistant Professor Machmer, Assistant
Professor Duncan and Mr. Hazeltine.

Elective Courses.

26. **2.** PLANE SURVEYING.—For Sophomores, Juniors and Seniors may elect. The elements of the subject, including the adjustment and use of the usual instruments. Text-book and lectures.
2 class hours. Credit 2.

Professor Ostrander, Assistant Professor Duncan,
Assistant Professor Machmer and Mr. Hazeltine.

27. **3.** PLANE SURVEYING.—For Sophomores, Juniors and Seniors may elect. As stated under Course 26. Includes field work.
3 2-hour laboratory periods, credit 3.

Professor Ostrander, Assistant Professor Duncan,
Assistant Professor Machmer and Mr. Hazeltine.

Prerequisite, Mathematics 26.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24	inclusive	Freshmen
25 to 49	"	Sophomores
50 to 74	inclusive	Juniors
75 to 99	"	Seniors

50. **1.** ANALYTIC GEOMETRY.—For Juniors, Seniors may elect. A discussion of the geometry of the line, the circle of conic sections and of the higher plane curves. Fine and Thompson's "Coordinate Geometry."
3 class hours. Credit 3.
Assistant Professor DUNCAN.
Prerequisites, Mathematics 1, 2, 3 and 5.

51. **2.** DIFFERENTIAL AND INTEGRAL CALCULUS.—For Juniors, Seniors may elect. A first course in the subject, with some of the more important applications. Davis's "Differential and Integral Calculus."
5 class hours. Credit 5.
Assistant Professor DUNCAN.
Prerequisites, Mathematics 1, 2, 3 and 5.

52. **3.** INTEGRAL CALCULUS.—For Juniors, Seniors may elect. A continuation of Course 51.
5 class hours. Credit 5.
Assistant Professor DUNCAN.
Prerequisite, Mathematics 51.

53. **2.** ELEMENTARY STRUCTURES.—For Juniors, Seniors may elect. An elementary course in roofs and bridges. Text-book and lectures.
3 class hours. 1 2-hour laboratory period, credit 4.
Professor OSTRANDER.

75. **1.** HYDRAULICS AND SANITARY ENGINEERING.—For Seniors, Juniors may elect. Hydrostatics, theoretical hydraulics, orifices, weirs, pipes, conduits, water supply, hydraulic motors, sewers and sewage treatment. Text-book and lectures.
5 class hours. Credit 5.
Professor OSTRANDER.

76. **1.** MATERIALS OF CONSTRUCTION, FOUNDATIONS AND MASONRY CONSTRUCTION.—For Seniors, Juniors may elect. Text-book and lectures.
4 class hours. 1 2-hour laboratory periods, credit 5.
Professor OSTRANDER.

77. **2.** ROADS AND RAILROADS.—For Seniors, Juniors may elect. Topographic and higher surveying, highway construction, earthwork, pavements and railroad construction. Text-book and lectures.
3 class hours. Credit 3.
Professor OSTRANDER.

78. **3.** ROADS AND RAILROADS.—For Seniors, Juniors may elect. As stated under Course 77.
3 2-hour laboratory periods, credit 3.
Professor OSTRANDER.
Prerequisite, Mathematics 77.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

79. **1.** APPLIED MECHANICS.—Seniors. A course in applied mechanics, based on the calculus, with problems. Text-books and lectures.
5 class hours. Credit 5.
Professor OSTRANDER.

Prerequisite, Mathematics 51.

MICROBIOLOGY.

Professor MARSHALL, Associate Professor VANSUCHTELEN, MR. ITANO, MR. AVERY

(Courses 50 and 51 are especially adapted to those who wish a general comprehensive, although elementary, survey of agricultural microbiology).

Elective Courses.

50. **1 and 3.** INTRODUCTION AND GENERAL MICROBIOLOGY.—For Juniors, Seniors may elect. A review of the field of Microbiology as a whole, with special reference to Hygienic Microbiology, will constitute this course. It will be taught by means of lectures, demonstrations and text-books. Although desirable, it will not be required as a prerequisite to all courses that follow, and may be taken along with Course 51.
5 class hours. Credit 5.
MICROBIOLOGY DEPARTMENT.

51. **1. 2 and 3.** MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY.—For Juniors, Seniors may elect. Types of micro-organisms, technic of handling, methods of culture and functions of micro-organisms are considered. This course is elementary and fundamental to all applied and special microbiological studies, and therefore is made a prerequisite to all courses following. One hour will be scheduled.
10 laboratory hours, credit 5.
MICROBIOLOGY DEPARTMENT.

52. **3.** ADVANCED MORPHOLOGICAL, CULTURAL AND PHYSIOLOGICAL MICROBIOLOGY.—For Juniors, Seniors may elect. The purpose of this course is to prepare the student for a more intimate knowledge of microbiological agricultural problems. To accomplish this object it is necessary to provide more advanced technic and methods of culture, together with a more extensive knowledge of micro-organisms and their functions. One hour will be scheduled.
10 laboratory hours, credit 5.
MICROBIOLOGY DEPARTMENT.

Prerequisites, Microbiology 50 and 51.

75. **2.** AGRICULTURAL MICROBIOLOGY.—For Seniors, Juniors may elect. This general comprehensive course is designed to cover in an elementary manner those subjects only which confront the student of general agriculture,—the microbiological features of air, water, sewage, soil, dairy, fermentations, food,

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vaccines, antisera, microbial plant infections, methods and channels of infections, immunity and susceptibility, microbial infections of man and animals, methods of control or sanitary and hygienic practices. One hour will be scheduled.

10 laboratory hours, credit 5.
MICROBIOLOGY DEPARTMENT.

Prerequisite, Microbiology 51.

76. **3.** AGRICULTURAL MICROBIOLOGY.—For Seniors, Juniors may elect. As stated under Course 75. One hour will be scheduled.

10 laboratory hours, credit 5.
MICROBIOLOGY DEPARTMENT.

Prerequisites, Microbiology 52 and 75.

80. **2.** SOIL MICROBIOLOGY.—For Seniors, Juniors may elect. Such subjects as the number and development of micro-organisms in different soils; the factors which influence their growth, food, reaction, temperature, moisture and aeration; the changes wrought upon inorganic and organic matter in the production of soil fertility, ammonification, nitrification and denitrification; fixation of nitrogen symbiotically and non-symbiotically; methods of soil inoculation receive attention. One hour will be scheduled.

10 laboratory hours, credit 5.
MICROBIOLOGY DEPARTMENT.

Prerequisite, Microbiology 51.

81. **1.** HYGIENIC MICROBIOLOGY.—For Seniors, Juniors may elect. An attempt will be made to select for this course certain material which should be the possession of every individual, and which is basic to public hygiene and sanitation, as applied to man and animals. The microbiology of water supplies, food supplies, vaccines, antisera or antitoxins; the channels by which micro-organisms enter the body, the influence of body fluids and tissues upon them, body reactions with micro-organisms (susceptibility and immunity); the micro-organisms of some of the most important infectious diseases, methods of control including disinfectants and disinfection, antiseptics, antisepsis and asepsis will be treated. One hour will be scheduled.

10 laboratory hours, credit 5.
MICROBIOLOGY DEPARTMENT.

Prerequisites, Microbiology 50 and 51.

82. **1.** DAIRY MICROBIOLOGY.—For Seniors, Juniors may elect. Special emphasis will be placed upon milk supplies. The microbial content of milk, its source, its significance, its control; microbial taints and changes in milk; groups or types of organisms found in milk; milk as a carrier of disease-producing organisms; the value of straining, aeration, centrifugal separation, temperature, pasteurization; the abnormal fermentations of milk; bacteriological milk standards and their interpretation; ripening of milk and cream; the bac-

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

terial content of butter; a passing survey of the microbiology of cheeses; a study of special dairy products, as ice cream, condensed milk, artificial milk drinks (the products of microbial actions), represents a list of topics considered.

10 laboratory hours, credit 5.

MICROBIOLOGY DEPARTMENT.

Prerequisites, Microbiology 51, Dairying 51.

83. **1.** FOOD MICROBIOLOGY.—For Seniors, Juniors may elect. A study of food preservation by means of drying, canning, refrigerating and addition of chemicals will be pursued. Food fermentations, as illustrated by bread, pickles, sauerkraut, ensilage, vinegar, wine, etc., will be examined. Decomposition of foods, as may be seen in meat, oysters, fish, milk, etc., as well as diseased foods, will receive consideration. Contamination of food supplies by means of water, handling, exposure, diseased persons, etc., is of especial significance and will be demonstrated by laboratory exercises. One hour will be scheduled.

10 laboratory hours, credit 5.

MICROBIOLOGY DEPARTMENT.

Prerequisite, Microbiology 51.

PHYSICS.

Professor HASBROUCK, Assistant Professor ROBBINS, MR. THOMPSON.

(The fundamental and basic importance of the laws and phenomena of physics makes necessary no explanation of the introduction of this subject into the curriculum of an agricultural college. The logical development of the subject emphasizes the importance of physics as a science in itself. Special emphasis is laid, however, on the correlation of the principles studied with the sciences of agriculture, botany, chemistry, zoology, thus furnishing an extra tool by use of which the student's work in all the subjects may be more effective).

Required Courses.

25. **1.** GENERAL PHYSICS.—Sophomores. Mechanics of Solids and Fluids. This course includes statics, with equilibrium of rigid bodies, work, energy and friction; kinetics, considering rectilinear motion and motion in a curved path; harmonic motion; rotation of rigid bodies, including kinematics of rotation; liquids and gases, with properties of fluids at rest and in motion; properties of matter and its internal forces, including elasticity, capillarity, surface tension.

3 class hours. 1 2-hour laboratory period, credit 4.

Professor HASBROUCK, Assistant Professor ROBBINS, MR. THOMPSON.

26. **2.** ELECTRICITY AND MAGNETISM.—Sophomores. The work in electricity includes such subject matter as magnetism, electrostatics, electric currents with their production, chemical, heating and mechanical effects; battery cells, measurement of voltage, current flow and resistance, motors and generators.

2 class hours. 1 2-hour laboratory period, credit 3.

Assistant Professor ROBBINS and MR. THOMPSON.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

Elective Courses.

27. **3.** HEAT AND LIGHT.—For Sophomores, Juniors and Seniors may elect. Thermometry, expansion, colorimetry and specific heat, transmission of heat, changes of state, radiation and absorption. Wave theory of light, optical instruments, analysis of light, color, interference, diffraction, polarization.
4 class hours. 1 2-hour laboratory period, credit 5.
Professor HASBROUCK, Assistant Professor ROBBINS and MR. THOMPSON.

50. **1.** ELECTRICITY, HEAT AND LIGHT.—For Juniors, Seniors may elect.
1 class hour. 2 2-hour laboratory periods, credit 3.
Assistant Professor ROBBINS.

51. **2.** ELECTRICITY, HEAT AND LIGHT.—For Juniors, Seniors may elect. Continuation of Course 50.
1 class hour. 2 2-hour laboratory periods, credit 3.
Assistant Professor ROBBINS.

Prerequisite, Physics 50.

52. **3.** ELECTRICITY, HEAT AND LIGHT.—For Juniors, Seniors may elect. Continuation of Courses 50 and 51.
1 class hour. 2 2-hour laboratory periods, credit 3.
Assistant Professor ROBBINS.

Prerequisite, Physics 51.

VETERINARY SCIENCE.

Professor PAIGE, Associate Professor GAGE.

(The courses in veterinary science have been arranged to meet the needs of students who propose following practical agriculture, and of prospective students of human and comparative medicine.)

Elective Courses.

50. **1.** VETERINARY HYGIENE AND STABLE SANITATION.—For Juniors, Seniors may elect. This course is intended to familiarize the student with the relation of water, food, air, light, ventilation, care of stables, disposal of excrement, individual hygiene, etc., to the prevention of disease in farm animals.
5 class hours. Credit 5.
Professor PAIGE.

51. **2.** GENERAL VETERINARY PATHOLOGY, MATERIA MEDICA AND THERAPEUTICS.—For Juniors, Seniors may elect. In this course such fundamental and general pathological conditions are studied as inflammation, fever, hypertrophy, atrophy, etc., a knowledge of which is essential in the diagnosis, prevention and treatment of disease. The course in pathology is followed by one in materia medica and therapeutics, dealing with the origin, preparation,

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

pharmacology, pharmacy, administration and therapeutic use of the more common drugs. Poisonous plants and symptoms and treatment of plant poisoning are also considered.
5 class hours. Credit 5.
Professor Paige.

75. **1.** COMPARATIVE (VETERINARY) ANATOMY.—For Seniors, Juniors may elect. The anatomy of the horse is studied in detail, and that of other farm animals compared with it where differences exist. This course is essential for those students wishing to elect Course 76.
5 class hours. Credit 5.
Professor Paige.

76. **2.** THEORY AND PRACTICE OF VETERINARY MEDICINE; GENERAL, SPECIAL AND OPERATIVE SURGERY.—For Seniors, Juniors may elect. A course intended to familiarize the student with the various medical and surgical diseases of the different species of farm animals. Particular attention is given to diagnosis and first-aid treatment. The student is taught the technic of simple surgical operations that can with safety be performed by the stock owner. Lectures, demonstrations and practice. This course should be taken in conjunction with Course 51.
5 class hours. Credit 5.
Professor Paige.

Prerequisite, Veterinary 75.

78. **1.** ESSENTIALS OF GENERAL PATHOLOGY.—For Seniors, Juniors may elect. This course is planned to introduce the student to some of the essential anatomical, histological and general physiological phenomena essential to the understanding of some of the simple general pathological conditions found in domestic animals. Some of the common methods of diagnosis will be considered in the laboratory. The various chemical and biological reactions and tests will be presented from the standpoint of pure science, showing applications of chemistry and biology. The course will serve to liberally educate and stimulate in the student of agriculture the appreciation of some of the methods used in animal pathology for detecting and controlling some of the more common animal diseases. Lectures, demonstration and laboratory work.
2 3-hour laboratory periods, credit 3.
Associate Professor Gage.

79. **2.** ESSENTIALS OF GENERAL ANIMAL PATHOLOGY.—For Seniors, Juniors may elect. This is a continuation of Course 78, and is devoted to a study of some of the common pathological conditions by means of prepared sections, the aim being to demonstrate to the student abnormal animal histological structures commonly observed when material from various cases of animal diseases is prepared for microscopical study. Some of the biological products used in protecting animals against disease will be considered.
2 3-hour laboratory periods, credit 3.
Associate Professor Gage.

Prerequisite, Veterinary 78.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

80. **3.** ESSENTIALS OF GENERAL ANIMAL PATHOLOGY.—For Seniors, Juniors may elect. As stated in Courses 78 and 79.

2 3-hour laboratory periods, credit 3.
Associate Professor Gage.

Prerequisite, Veterinary 79.

85. **1.** AVIAN PATHOLOGY.—For Seniors, Juniors may elect. A course in poultry diseases. The object of this course is to present information concerning the common diseases of poultry, their etiology, diagnosis and prevention. The work will consist of a systematic study of the diseases of the alimentary tract, liver and abdominal region, followed by a study of the diseases of the respiratory system, circulation and kidneys. The important disease-producing external and internal parasites will be considered; also diseases of the skin and reproductive organs. Lectures and demonstrations.

2 3-hour laboratory periods, credit 3.
Associate Professor Gage.

86. **2.** AVIAN PATHOLOGY.—For Seniors, Juniors may elect. As stated under Course 85, also devoted to the study of some of the special diseases of poultry. Recent methods used in the control of these diseases will be considered and opportunity offered the student for demonstrating various disease processes by means of prepared slides. Lectures, demonstrations and laboratory work.

2 3-hour laboratory periods, credit 3.
Associate Professor Gage.

Prerequisite, Veterinary 85.

87. **3.** AVIAN PATHOLOGY.—For Seniors, Juniors may elect. As stated under Courses 85 and 86.

2 3-hour laboratory periods, credit 3.
Associate Professor Gage.

Prerequisite, Veterinary 86.

ZOÖLOGY AND GEOLOGY.

Associate Professor Gordon.

Zoölogy.

Required Courses.

25. **1.** GENERAL ZOOLOGY.—Sophomores. This course gives an outline of the underlying principles of Zoölogy and an introduction to animal structure.

1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor Gordon and Assistant.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

Elective Courses.

27. **3.** ELEMENTS OF MAMMALIAN ANATOMY.—For Sophomores, Juniors and Seniors may elect. This course is offered as a preparation for work in histology, embryology, general vertebrate zoölogy, etc. It also deals briefly with the essentials of physiology. The course is open to prospective students in physiological chemistry, microbiology, animal husbandry, veterinary sciences, etc.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor GORDON and Assistant.

Prerequisite, Zoölogy 25.

50. **1.** SYNOPTIC INVERTEBRATE ZOÖLOGY.—For Juniors, Seniors may elect. This course gives a synopsis of the distinguishing characters of the different phyla and classes of invertebrates.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor GORDON and Assistant.

Prerequisite, Zoölogy 25.

51. **2.** SYNOPTIC INVERTEBRATE ZOÖLOGY.—For Juniors, Seniors may elect. Continuation of Course 50.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor GORDON and Assistant.

Prerequisite, Zoölogy 50.

52. **3.** SYNOPTIC INVERTEBRATE ZOÖLOGY.—For Juniors, Seniors may elect. Continuation of Courses 50 and 51.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor GORDON and Assistant.

Prerequisite, Zoölogy 51.

53. **1.** ELEMENTS OF MICROSCOPIC TECHNIQUE.—For Juniors, Seniors may elect. This course gives methods of preparing material for microscopic examination.
3 2-hour laboratory periods, credit 3.
The DEPARTMENT.

Prerequisite, Zoölogy 25.

54. **2.** ELEMENTS OF HISTOLOGY.—For Juniors, Seniors may elect. This course involves preparation and study of normal animal tissues.
3 2-hour laboratory periods, credit 3.
The DEPARTMENT.

Prerequisites, Zoölogy 27 and 53.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

55. **3.** ELEMENTS OF HISTOLOGY.—For Juniors, Seniors may elect. Continuation of Course 54.

3 2-hour laboratory periods, credit 3.
The DEPARTMENT.

Prerequisite, Zoölogy 54.

75. **1.** ADVANCED ZOÖLOGY.—For Seniors and Graduate Students. Students who are adequately prepared may elect special work in general embryology, vetebrate embryology, comparative invertebrate zoölogy, comparative vertebrate zoölogy, etc.

2 class hours. 3 2-hour laboratory periods, credit 5.
The DEPARTMENT.

Prerequisites: Depending on elective.

76. **2.** ADVANCED ZOÖLOGY.—For Seniors and Graduate Students. As stated under Course 75.

2 class hours. 3 2-hour laboratory periods, credit 5.
The DEPARTMENT.

Prerequisites: Depending on elective.

77. **3.** ADVANCED ZOÖLOGY.—For Seniors and Graduate Students. As stated under Courses 76.

2 class hours. 3 2-hour laboratory periods, credit 5.
The DEPARTMENT.

Prerequisites: Depending on elective.

Foot Note: The work offered in Zoölogy 50, 51, 52, 75, 76 and 77 may apply on a minor for the degrees of Master of Science or Doctor of Philosophy.

GEOLOGY.

Required Courses.

2. **2.** AGRICULTURAL GEOLOGY.—Freshmen. The elements of geology in their application to agriculture.

2 class hours. Credit 2.
Associate Professor GORDON.

Elective Courses.

27. **3.** GENERAL GEOLOGY.—For Sophomores, Juniors and Seniors may elect. Rock-forming minerals; rock types; rock weathering; dynamical, structural and surface geology. Lectures, map and field work.

3 class hours. 2 2-hour laboratory periods, credit 5.
Associate Professor GORDON.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:
1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

DIVISION OF THE HUMANITIES.

Professor SPRAGUE.

ECONOMICS AND SOCIOLOGY.

Professor SPRAGUE.

(The courses in economics and sociology are planned with the purpose of giving the student that knowledge and understanding of the important factors and problems in this field of study and life which every active citizen and educated man ought to have.)

Elective Courses.

26. **2.** ANTHROPOLOGY; THE HISTORY OF HUMAN CIVILIZATION.—For Sophomores, Juniors and Seniors may elect. The evolutionary origin and history of man; characteristics of primitive men, departure from the animal status, and the beginnings of civilization; development of industries, arts and sciences; the growth of languages, warfare, migrations and social institutions; a study of the powerful natural and human forces that have brought man from the early stages to modern conditions; characteristics of the leading races of the world. These topics will constitute the subject-matter of the course. Library readings, text-book and lectures.

5 class hours. Credit 5.

Professor SPRAGUE.

50. **1.** INDUSTRIAL PROBLEMS.—For Juniors, Seniors may elect. This is a course in the most important industrial problems of the day, covering the methods of organizations of labor and capital, systems of industrial remuneration, means of securing industrial peace, legal status of labor unions and their activities, protective legislation for workmen and employers, the problems of immigration, the sweated industries, prison labor, child labor and industrial education. Text-book, with collateral readings, lectures and discussion.

5 class hours. Credit 5.

Professor SPRAGUE.

51. **2.** POLITICAL ECONOMY.—For Juniors, Seniors may elect. An introductory course which takes up the study of the nature and scope of economics, the evolution and organization of the present economic system, and the fundamental principles of production, exchange and consumption. The class will study and discuss such topics as wealth, value, capital, interest, profits, wages and labor, tariffs, trusts, etc. Debates on current economic problems will be organized in the class. Text-book, library readings, lectures and discussions.

5 class hours. Credit 5.

Professor SPRAGUE.

52. **3.** PUBLIC FINANCE, MONEY AND BANKING.—For Juniors, Seniors may elect. This course follows Economics 51. It will take up taxation and the various systems for collecting public revenue in Europe and America, with the problems involved; the history of money and the systems of banking and finance now in operation; the cause and problems of economic crises and depressions; the currency problems of the United States. Readings, lectures and discussions.

5 class hours. Credit 5.

Professor SPRAGUE.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

75. **1.** SOCIAL INSTITUTIONS AND SOCIAL PROBLEMS.—For Seniors, Juniors may elect. This course is devoted to the study of the social institutions, such as the family, the church, State and property; and to such current social problems as divorce, race suicide, crime and prison reform, poverty and its relief. Considerable time is given to the study of eugenics in its social significance and possibilities. The correctional and charitable institutions of Massachusetts are studied in some detail. The later weeks of the term are devoted to a short introduction to sociological theory. Readings, lectures, discussions.
5 class hours. Credit 5.
Professor SPRAGUE.

76. **2.** MODERN SOCIAL REFORM MOVEMENTS.—For Seniors, Juniors may elect. The history of property and its vital issues in modern times; the socialistic systems, anarchy and communism; systems of workingmen's insurance in Europe and America, and other methods of relief from the chances of life; educational reforms, in process, to meet the demands of a new age, and legislative remedies for the evils of social change and maladjustment; the crisis of Christianity under modern capitalized industrialism. These topics indicate the nature of the subjects studied. This course is arranged to follow Economics 75.
5 class hours. Credit 5.
Professor SPRAGUE.

HISTORY AND GOVERNMENT.

Elective Courses.

50. **1.** ELEMENTS OF POLITICAL SCIENCE.—For Juniors, Seniors may elect. Nature and scope of political science; origin and evolution of the State; systems of government in the principal European States; organization and working of the national and of the State governments of the United States; relation of government to political parties and to public opinion; the functions of government as related to labor and commerce. (Withheld in 1915-16).
3 class hours. Credit 3.
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51. **2.** LOCAL POLITICAL INSTITUTIONS.—For Juniors, Seniors may elect. A comparative study of the organization, functions and achievements of country and city groups, especially as these are concerned with such matters as taxation, finance, licenses, franchises, public ownership, highways, transportation and communication, water supply, fire protection, public lighting, markets, food inspection, garbage and sewage disposal, infectious diseases, housing conditions, police force, parks and playgrounds, libraries, schools, care of dependents. (Not given in 1915-16).
3 class hours. Credit 3.
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75. **2.** THE HISTORY OF NEW ENGLAND.—For Seniors, Juniors may elect. This course, treating New England as a unit, aims to give a survey of its

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

political, religious and economic history; to trace the development of its institutions, the growth of its industries, and its influence in national politics and upon the newer sections of the United States. Assigned readings and themes.
3 class hours. Credit 3.

76. **3.** THE HISTORY OF IDEALS.—For Seniors, Juniors may elect. This course treats history from the idealistic rather than from the economic point of view. It attempts to define the great ideals which have impelled some of the most important social, political, esthetic, scientific, ethical and religious movements of medieval and modern history, and to trace the causes of the success or failure of the movements to which these ideals have led. Christianity, including monasticism, modern Catholicism and Protestantism; medieval art and architecture; the modern scientific movement; and social and political democracy will be treated historically from this point of view. (Withheld in 1915-16). Lectures and reading.
3 class hours. Credit 3.

LANGUAGES AND LITERATURE.

Professor Lewis, Associate Professor Neal, Associate Professor Ashley, Associate Professor Mackimmie, Assistant Professor Smith, Assistant Professor Prince, Miss Goessmann, Mr. Harmount, Mr. Julian, Mr. Rand.

English.

Required Courses.

1-**1.** 2-**2.** and 3-**3.** ENGLISH.—Freshmen. Composition. Recitations, laboratory practice and lectures; theme writing and conferences. Text-book and laboratory manual, Neal's "Thought-Building in Composition."
3 class hours each term. Credit 3 each term.
Assistant Professor Smith, Assistant Professor Prince and Mr. Rand.

25-**1.** 26-**2.** and 27-**3.** ENGLISH.—Sophomores. A general reading course in English literature.
2 class hours each term. Credit 2 each term.
Professor Lewis and Miss Goessmann.
Prerequisites, English 1, 2 and 3.

Elective Courses in English Language and Literature.

(The elective courses in English fall into two groups. Both groups are intended to increase the student's appreciation of literature as a means to enjoyment, education and spiritual growth. Group one (Courses 50, 51, 52, 53, 54 and 55) will, besides introducing the student to individual writers, emphasize the life and thought of the times, political, economic and social, in order that the student may realize literature as the expression of individual genius representing (by leading it or summarizing it) the thought and spirit of a period or a social unit. Group two (Courses 75, 77, 79 and 80) will tend more to emphasize form-characteristics, artistic quality or historcial development of literary types, or individual great writers. Courses 50, 51, 55, 75, 79 and 80 are offered in 1916-17; courses 52, 53, 54, 55, 77 and 80 are offered in 1915-16 and 1917-18.)

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

50. **1.** ENGLISH WRITERS AND THOUGHT.—Alternates with Course 53. *Verse from* 1744 *to* 1832 (1916, 1918).—For Juniors, Seniors may elect. A course in history, appreciation and understanding. Between the years named we see the rapid decline in formalism and a rapid increase of originality, freedom and emotional quality in literature (romanticism), accompanying the appearance in England of liberalism, industrial development, more general education and the spread of the ideals of democracy, and influenced also by Continental thought, especially the spirit of the French Revolution. This is the time in which England entered definitely upon that period of modern struggle, change and reorganization which is to be seen still continuing in contemporary affairs. Some of the writers belonging to it are Thomson, Collins, Gray and Cowper, Goldsmith, Chatterton, Blake, Crabbe, Burns, Coleridge, Wordsworth, Keats, Shelley, Scott and Byron.

3 class hours. Credit 3.

Assistant Professor Smith.

51. **2.** ENGLISH WRITERS AND THOUGHT.—Alternates with Course 54. *Nineteenth Century Verse* (1915, 1917).—Juniors, Seniors may elect. In general conception this course is like Course 50, which see. It begins with literature under the economic and social conditions of Victorian England, involving the advance of democracy, the spread of knowledge and culture, the advance of science, and the increase of industrialism, accompanied somewhat by materialism. The literature of the period takes new forms and directions; among its characteristics is an earnest endeavor to interpret ideals to a vastly increased and incompletely prepared reading public (''social service''). Tennyson, Browning, Mrs. Browning, Arnold, the Rossettis and Morris, Swinburne and Clough are among its noteworthy authors. Contemporary verse-writers will receive some notice.

3 class hours. Credit 3.

Professor Lewis.

52. **3.** ENGLISH WRITERS AND THOUGHT.—*From Milton to Pope* (1915-17).—For Juniors, Seniors may elect. A survey course. It begins with a brief review of the Elizabethan period, and then considers the period of Milton (Caroline literature—Puritanism, the civil wars, Cromwell and the Protectorate) followed by the rapidly changing political and social conditions of the Restoration and then of the Revolution, ending with the Augustan age and Pope, and the temporary predominance of classicism and the intellectual instead of emotional qualities in literature. It will, however, emphasize the leading writers of the periods, including Bacon, Milton, Dryden, Addision and the essayists, Swift and Pope. Much of the literature of these times is closely associated with interesting and most important events in English political, religious and social history that introduce and explain the later modern periods. Given every second year.

3 class hours. Credit 3.

Assistant Professor Smith.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

53. **1.** ENGLISH WRITERS AND THOUGHT.—Alternating with Course 50. *Prose from* 1744 *to* 1832 (1915, 1917). For Juniors, Seniors may elect. A course in English prose paralleling Course 51, which see. Some of the writers belonging to the period are Johnson, Sterne, Goldsmith, Burke, Miss Burney, Coleridge, Landor, Lamb, DeQuincey and Hazlitt. The political essayists and the reviews will receive attention, but prose writers whose principal work was done in the novel will not be emphasized (see Course 75).
3 class hours. Credit 3.
Assistant Professor Smith.

54. **3.** ENGLISH WRITERS AND THOUGHT.—Alternating with Course 51. *Nineteenth Century Prose* (1916, 1918). For Juniors, Seniors may elect. This course parallels Course 51, which see. Among the writers discussed will be Macaulay, Carlyle, Ruskin, Newman, historians (*e. g.*, Pater, Arnold and Symonds). Fiction writers are given little attention (see Course 75), but contemporary writers of other prose will be given some notice.
2 class hours. Credit 2.
Professor Lewis.

55. **2.** AMERICAN WRITERS AND THOUGHT.—For Juniors, Seniors may elect. Intended to give a general survey of literature in America, especially in the nineteenth century, with an introduction to the work of the best-known writers, and with especial attention to the relations between national life and history and national thought as expressed in literature. The usual authors—Irving, Cooper, Bryant, Poe, Longfellow, Emerson, Hawthorne, Whittier, Parkman, Lowell, Holmes, Whitman, Lanier—will be discussed, and attention will be given to southern and western authors. Present writers and tendencies will also receive some notice.
3 class hours. Credit 3.
Assistant Professor Prince.

56. **3.** AMERICAN WRITERS AND THOUGHT.—For Juniors, Seniors may elect. As stated under Course 55.
2 class hours. Credit 2.
Assistant Professor Prince.

60. **1.** THE LITERATURE OF RURAL LIFE.—For Juniors, Seniors may elect. A critical and appreciative study of writers, both in prose and poetry, who have interpreted nature from the viewpoint of the lover of country life, and those who have idealized agriculture, horticulture and other rural pursuits, together with those who have upheld as an ideal the development of a rural environment in cities.
3 class hours. Credit 3.
Miss Goessmann.

61. **2.** THE LITERATURE OF RURAL LIFE.—For Juniors, Seniors may elect. As stated under Course 60.
2 class hours. Credit 2.
Miss Goessmann.

Prerequisite, English 60.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:
1 to 24 inclusive Freshmen
25 to 49 " Sophomores
50 to 74 inclusive Juniors
75 to 99 " Seniors

75. **3.** PROSE FICTION.—Alternating with Course 77. *The Novel* (1916, 1918).—For Seniors, Juniors may elect. Readings, references, reports and class-room talks. The course is mainly informal. Among the results that may follow the study of the novel are: (a) a sense of critical method, springing from the consideration of historical development and of types; (b) a deepened humanism, consequent on the study of acts and motives of men and the influences that modify them; (c) increased appreciation of artistic method and form; and (d) acquaintance with a kind of literature that has grown into great importance through the popularizing of science, the downward extension of learning, and the democratizing of society.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor NEAL.

77. **3.** PROSE FICTION.—Alternating with Course 75. *The Short Story* (1915, 1917).—For Seniors, Juniors may elect. Readings, references, reports and class-room talks. The course is mainly informal. General texts, Neal's ''Short Stories in the Making'' and ''To-day's Short Stories Analyzed.'' Particular results that may be obtained from short-story study are: (a) self-culture, the short story being well adapted to stimulate the literary, dramatic and imaginative faculties; and (b) acquaintance with that type in which American literature has especially succeeded.
1 class hour. 2 2-hour laboratory periods, credit 3.
Associate Professor NEAL.

79. **2.** THE DRAMA AND SHAKSPERE.—For Seniors, Juniors may elect. The source, technique and development of drama, accompanied by a study of Shakspere, his mind, manner and technique. The minor Elizabethan dramatists, their influence on Shakspere, and Shakspere's influence on later writers, will be considered, as will the English social and industrial conditions of the time, their causes and their influence on Shakspere and his fellow writers. Extensive reading, analysis and interpretation of his comedies, tragedies and histories, and of modern dramatists is included.
3 class hours. Credit 3.
Assistant Professor SMITH.

80. **3.** THE DRAMA AND SHAKSPERE. For Seniors, Juniors may elect. As stated under Course 79.
2 class hours. Credit 2.
Assistant Professor SMITH.

RURAL JOURNALISM.

(The courses in journalism emphasize rural journalism. They aim to acquaint the student with the elementary problems and theory of journalism as a profession or vocation, and to exercise him, as far as conditions permit, in the commoner aspects of journalistic work, such as news-gathering, news-writing, desk-editing and editorial writing. By rural journalism is meant the application of journalistic principles in getting and suitably presenting material adapted to the non-urban rather than to the urban or metropolitan reader, so far as their interests are distinct. This includes agricultural journalism, but is by no means confined to that. As practical work, members of the classes supply "The Bay State Ruralist," a feature page for the Springfield Sunday Union.)

Elective Courses.

50. **1.** FOUNDATIONS OF WRITING; EXPOSITION.—For Juniors, Seniors may elect. Advanced composition; planning expository thought; expository structure; analysis of specimens, including contemporary articles from farm and rural life publications, bulletins, etc.; some bulletin writing, including presentation of technical information for nontechnical readers.
3 class hours. Credit 3.
Associate Professor NEAL.

51. **2.** FOUNDATIONS OF WRITING; NARRATION AND DESCRIPTION.—For Juniors, Seniors may elect. The fundamental elements of style, word-choice, diction, sentence form and paragraph types. Description of persons, places, objects, industries and productional processes, the temper and characteristic aspects of public gatherings, moods, behavior and character-sketching. Narration of incident, sustained action, events in series and the like, as in biography, dramatic situation, history and fiction.
3 class hours. Credit 3.
Associate Professor NEAL.

52. **3.** FOUNDATION OF WRITING, SPECIAL WRITING.—For Juniors, Seniors may elect. As stated under Courses 50 and 51.
3 class hours. Credit 3.
Associate Professor NEAL.

Prerequisite, Journalism 51.

53. **1.** NEWS-GATHERING AND NEWS-WRITING.—For Juniors, Seniors may elect. The foundation aims and conceptions of journalism. Readings, lectures, quizzes and personal conferences; reporting on runs and on assignment; regular reading of a daily paper and of a weekly review or farm journal, with reports thereon. The central purpose is to develop ability to pick out essentials from inessentials, perceive elements of interest, and present facts with appeal to the reader. (Further practice is provided in Courses 81 and 82.) Though given somewhat informally, the year's work will bring before the student such subjects as these: City and rural newspapers, class and trade journals, reviews, magazines. Journalistic style. Nature, classes and tests of news. News values. Form of the news story; lead and feature. Stories not primarily news; feature and human-interest stories, etc. News sources; runs, assignments, correspondents. News in the home community; farm reporting; employment of news to develop home interests. This course and Course 4 are recommended to students whose vocation will require the popular presentation of technical or other information; *e.g.*, extension workers, county agents, agricultural school instructors, experiment-station editors, survey and other social service workers, men engaged in sociological or economic investigations, landscape architects, and civil and sanitary engineers. Students desiring practice in the writing of special, magazine and feature articles might find this course adapted to their purpose. 6 laboratory hours, credit 3.
Associate Professor NEAL.

54. **2.** NEWS-GATHERING AND NEWS-WRITING.—For Juniors, Seniors may elect. As outlined under Course 53, except that students who have

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Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

taken Course 53 will be assigned different readings and may be given a larger amount of reporting or other writing.

6 laboratory hours, credit 3.
Associate Professor NEAL.

55. **3.** NEWS-GATHERING.—For Juniors, Seniors may elect. As stated under Courses 53 and 54.

6 laboratory hours, credit 3.
Associate Professor NEAL.

77. **1.** EDITORIAL MATERIALS AND METHODS.—For Seniors, Juniors may elect. Readings, quizzes, reports and personal conferences; regular reading of one daily paper and one weekly review or rural life periodical; writing of editorial articles; current events or history. Though given somewhat informally, the year's work will bring before the student such subjects as these: Editing as interpretation and as executive direction; the urban, the agricultural and the rural editor; relation of the editor to his community; editorial organization. The business side of editing. The newspaper as a public utility; its relations to community welfare. Editorial subjects and writing; sources of information; rural topics and their interpretation. Recommended to non-majoring students who desire practice in discovering the significant aspects of matters of public attention and in effectively expressing thought thereon. Laboratory course.

6 laboratory hours, credit 3.
Associate Professor NEAL.

78. **2.** EDITORIAL MATERIALS AND METHODS.—For Seniors, Juniors may elect. As stated under Course 77.

6 laboratory hours, credit 3.
Associate Professor NEAL.

79. **3.** EDITORIAL MATERIALS AND METHODS.—For Seniors, Juniors may elect. As stated under Course 77.

6 laboratory hours, credit 3.
Associate Professor NEAL.

80. **1.** ADVANCED JOURNALISTIC PRACTICE.—Seniors. Preparation, editing and publication of a rural life page or periodical. Members of the class are expected to make several trips to "The Springfield Union" offices on days when "The Bay State Ruralist" page is making up, and individual students may sometimes be placed in charge of the make-up. Recommended (like Courses 53 and 54) to students interested in writing special, magazine and feature articles.

8 or 10 laboratory hours, credit 4 or 5.
Associate Professor NEAL.

81. **2.** ADVANCED JOURNALISTIC PRACTICE.—Seniors. As stated under Course 80.

8 or 10 laboratory hours, credit 4 or 5.
Associate Professor NEAL.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

82. **3.** ADVANCED JOURNALISTIC PRACTICE.—Seniors. As stated under Course 80.

8 or 10 laboratory hours, credit 4 or 5.
Associate Professor NEAL.

PUBLIC SPEAKING.

Required Courses.

1. **1. 2 and 3.** PUBLIC SPEAKING.—Freshmen. Freshman public speaking is required in the first, second or third term, at the option of the instructor. The course is concerned with the actual problems which confront the man who would speak convincingly and persuasively. Some attention is given to breath control and development of speaking voice, considerable attention to pronunciation and enunciation, and a large amount of attention to the preparation and delivery of extempore speeches. Text-book, Shurter's "Extempore Speaking," supplemented by lectures and discussions. 1st, 2nd or 3d terms as directed.

1 class hour. Credit 1.
Assistant Professor PRINCE and MR. RAND.

Elective Courses.

50. **1.** DEBATING.—For Juniors, Seniors may elect. Considerable time is given to the study of argumentation and brief-drawing. The class is divided into teams for the platform discussion of leading questions of the day. This course is designed to develop readiness in extempore speaking. It is recommended for those who desire to enter the intercollegiate debates.

3 class hours. Credit 3.
Assistant Professor SMITH.

Prerequisite, Public Speaking **1.**

51. **2.** OCCASIONAL ORATORY.—For Juniors, Seniors may elect. Exercises for voice and gesture; a study of the elements of vocal expression and action; speeches on assigned topics; prescribed reading; the preparation and delivery of a formal oration or two. It is especially recommended for those who desire to enter the Flint contest.

3 class hours. Credit 3.
Assistant Professor SMITH.

FRENCH AND SPANISH.

Associate Professor MACKIMMIE, MR. HARMOUNT.

FRENCH.

Required Courses.

1. **1.** 2, **2.** 3, **3.** ELEMENTARY FRENCH.—Freshmen, open upon arrangement to other students. The essentials of grammar are rapidly taught and will be accompanied by as much reading as possible. This course is re-

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

quired of Freshmen presenting German for entrance who do not continue that language and have not studied French.
3 class hours each term. Credit 3, each term.
Mr. Harmount.

4, **1.** 5, **2.** 6, **3.** INTERMEDIATE FRENCH.—Freshmen, open upon arrangement to other students. Training for rapid reading. The reading of a number of short stories, novels and plays; composition, reports on collateral reading from periodicals and scientific texts in the Library.
3 class hours each term. Credit 3, each term.
Associate Professor Mackimmie, Mr. Harmount.

Prerequisite: Required of Freshmen who present two years of French for entrance and do not take German.

Elective Courses.

25. **1.** INTERMEDIATE FRENCH.—For Sophomores, open upon arrangement to other students. Training for rapid reading; the reading of a number of short stories, novels and plays; readings from periodicals and scientific texts in the Library.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisites, French 1, 2 and 3.

26. **2.** INTERMEDIATE FRENCH.—For Sophomores, open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, French 25.

27. **3.** INTERMEDIATE FRENCH.—For Sophomores, open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, French 25.

28. **1.** ADVANCED FRENCH.—For Sophomores, open upon arrangement to other students. A reading course. Balzac's ''Eugenie Grandet" and ''Le-Père Goriot" and other masterpieces of the nineteenth century; Brunetière's ''Honore de Balzac" and Harper's ''Masters of French Literature;" readings in the Library and written reports.
3 class hours. Credit 3.
Mr. Harmount.

Prerequisites, French 4, 5 and 6.

29. **2.** ADVANCED FRENCH.—For Sophomores, open upon arrangement to other students. As stated under Course 28.
3 class hours. Credit 3.
Mr. Harmount.

Prerequisite, French 28.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

30. **3.** ADVANCED FRENCH.—For Sophomores, open upon arrangement to other students. General view of the history of French literature; Kastner and Atkins' "History of French Literature," Representative works of the important periods will be studied in class. Outside reading will be required.
3 class hours. Credit 3.
Mr. Harmount.

Prerequisites, French 25 and 26, or French 28 and 29.

50. **1.** SCIENTIFIC FRENCH.—For Juniors, Seniors may elect. This course is planned to meet the requirements of the individual student and aims to equip him with exact English equivalents for the French scientific terms in his particular science. Word lists of scientific terms will be required and also weekly readings and reports from scientific works in the subject in which he is majoring. Several scientific readers will be read.
3 class hours. Credit 3.
Mr. Harmount.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

51. **2.** SCIENTIFIC FRENCH.—For Juniors, Seniors may elect. As stated under Course 50.
3 class hours. Credit 3.
Mr. Harmount.

Prerequisite, French 50.

52. **3.** SCIENTIFIC FRENCH.—For Juniors, Seniors may elect. As stated under Course 50.
3 class hours. Credit 3.
Mr. Harmount.

Prerequisite, French 51.

75. **1.** FRENCH LITERATURE.—For Seniors, Juniors may elect. The object of Courses 75, 76, and 77 is to give an introduction to recent movements in French literature. 75 will deal with the drama, and plays by Augier, A. Dumas, fils, Delavigne, and some contemporary dramatists will be read and studied.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisites, French 4, 5 and 6, or French 25, 26 and 27.

76. **2.** FRENCH LITERATURE.—For Seniors, Juniors may elect. This course deals with the novel. Works by Flaubert, the de Goncourts, and Zola will be read. Written reports are required on outside reading.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, French 75.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

77. **3.** FRENCH LITERATURE.—For Seniors, Juniors may elect. Modern criticism. Sainte-Beuve, Causeries de Lundi (Harper) and works by Taine, and Renan. Reference book, Lanson's ''Histoire de la Litterature Franciase.''
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, French 76.

Spanish.

Elective Courses.

50. **1.** ELEMENTARY SPANISH.—For Juniors, Seniors may elect. Open to other students upon arrangement. Grammar, with special drill in pronunciation; exercises in conversation and composition. Reading from a reader and selected short stories.
3 class hours. Credit 3.
Associate Professor Mackimmie.

51. **2.** ELEMENTARY SPANISH.—For Juniors, open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, Spanish 50.

52. **3.** ELEMENTARY SPANISH.—For Juniors, open to other students upon arrangement. As stated in Course 50.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, Spanish 51.

75. **1.** MODERN SPANISH AUTHORS.—Seniors. Reading from modern Spanish novel and drama. Translation of English into Spanish. Private reading.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, Spanish 52.

76. **2.** MODERN SPANISH AUTHORS.—Seniors. As stated in Course 75.
3 class hours. Credit 3.
Associate Professor Mackimmie.

Prerequisite, Spanish 75.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

77. **3.** MODERN SPANISH AUTHORS. Seniors. As stated in Course 75.
3 class hours. Credit 3.
Associate Professor MACKIMMIE.

Prerequisite, Spanish 76.

GERMAN AND MUSIC.

Associate Professor ASHLEY, MR. JULIAN.

GERMAN.

Required Courses.

1. **1.** 2. **2.** 3. **3.** ELEMENTARY GERMAN.—Freshmen, open upon arrangement to other students. Grammar composition and reading. Especial attention is given to oral work in German and to translation of English into German. Required of those presenting French for entrance who do not continue that language and have not studied German.
3 class hours, each term. Credit 3, each term.
Associate Professor ASHLEY and MR. JULIAN.

4. **1.** 5. **2.** 6. **3.** INTERMEDIATE GERMAN. Freshmen, open upon arrangement to other students. Selected works of Schiller, Heine and Goethe, Grammar review and advanced prose composition.
3 class hours, each term. Credit 3, each term.
Associate Professor ASHLEY.

Prerequisite: Required of Freshmen who present two years of German for entrance and do not take French.

Elective Courses.

25. **1.** INTERMEDIATE GERMAN.—For Sophomores, open upon arrangement to other students. Reading of such works as Sudermann's "Frau Sorge," "Wilhelm Tell," "Die Journalisten," etc. Grammar review.
3 class hours. Credit 3.
MR. JULIAN.

Prerequisites, German 1, 2, and 3.

26. **2.** INTERMEDIATE GERMAN.—For Sophomores, open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit 3.
MR. JULIAN.

Prerequisite, German 25.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

27. **3.** INTERMEDIATE GERMAN.—For Sophomores, open upon arrangement to other students. As stated under Course 25.
3 class hours. Credit 3.
Mr. Julian.

Prerequisite, German 26.

28. **1.** ADVANCED GERMAN.—For Sophomores, open upon arrangement to other students. Reading and studying of Goethe's most important literature productions.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisites, German 4, 5, and 6.

29. **2.** ADVANCED GERMAN.—For Sophomores, open upon arrangement to other students. As stated under Course 28.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisite, German 28.

30. **3.** ADVANCED GERMAN.—For Sophomores, open upon arrangement to other students. As stated under Course 28.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisite, German 29.

Elective Courses.

50. **1.** SCIENTIFIC GERMAN.—For Juniors, Seniors may elect. Reading in German of modern magazine articles and works of a scientific nature. Different work assigned according to needs of individual students.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisites, German, 4, 5 and 6, or German 25, 26 and 27.

51. **2.** SCIENTIFIC GERMAN.—For Juniors, Seniors may elect. As stated under Course 50.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisite, German 50.

52. **3.** SCIENTIFIC GERMAN.—For Juniors, Seniors may elect. As stated under Course 50.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisite, German 51.

75. **1.** GERMAN LITERATURE.—Seniors. Advanced language and literary study. Conducted entirely in German. Lectures on German literature

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

and history; life, customs and travel in Germany. Collateral readings, including masterpieces of different epochs, such as "Niebelungenlied," Goethe's "Faust," and one modern typical drama.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisites, German 28, 29 and 30.

76. **2.** GERMAN LITERATURE.—Seniors. As stated under Course 75.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisite, German 75.

77. **3.** GERMAN LITERATURE.—Seniors. As stated under Course 75.
3 class hours. Credit 3.
Associate Professor Ashley.

Prerequisite, German 76.

78. **1.** CONVERSATION AND COMPOSITION.—For Seniors, Juniors may elect. Translating connected English into German. Reproducing outside readings in German orally in class.
1 class hour. Credit 1.
Associate Professor Ashley.

Prerequisites, German 4, 5 and 6, or German 25, 26 and 27.

79. **2.** CONVERSATION AND COMPOSITION.—For Seniors, Juniors may elect. As stated under Course 78.
1 class hour. Credit 1.
Associate Professor Ashley.

Prerequisite, German 78.

80. **3.** CONVERSATION AND COMPOSITION.—For Seniors, Juniors may elect. As stated under Course 78.
1 class hour. Credit 1.
Associate Professor Ashley.

Prerequisite, German 79.

MUSIC.

Elective Courses.

50. **1.** HISTORY AND INTERPRETATION OF MUSIC.—For Juniors, Seniors may elect. History of music among the ancients; medieval and secular music; epoch of vocal counterpoint; development of monophony opera and oratorio; life and works of the greatest representatives of the classical school—Bach, Händel, Haydn, Gluck and Mozart.
1 class hour. Credit 1.
Associate Professor Ashley.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

51. **2.** HISTORY AND INTERPRETATION OF MUSIC.—For Juniors, Seniors may elect. A continuation of Course 50. The Romantic school; Beethoven, Schubert, Weber, Mendelssohn, Schumann, Chopin, Berlioz and Liszt; Wagner and the opera. The Modern school and Modern composers.
1 class hour. Credit 1.
Associate Professor ASHLEY.

52. **3.** HISTORY AND INTERPRETATION OF MUSIC.—For Juniors, Seniors may elect. As stated under Courses 50 and 51.
1 class hour. Credit 1.
Associate Professor ASHLEY.

DIVISION OF RURAL SOCIAL SCIENCE.

President BUTTERFIELD.

AGRICULTURAL ECONOMICS.

Professor CANCE, MR. HOTIS, MR. STRAND.

Required Course.

26. **2.** AGRICULTURAL INDUSTRY AND RESOURCES.—Sophomores. A descriptive course dealing with agriculture as an industry and its relation to physiography, movement of population, supply of labor, commercial development, transportation, public authority and consumers' demand. The principal agricultural resources of the United States will be studied with reference to commercial importance, geographical distribution, present condition and means of increasing the value of the product and cheapening cost of production. Lectures, assigned readings, class topics and discussions.
5 class hours. Credit 5.
Professor CANCE, MR. HOTIS, MR. STRAND.

Elective Courses.

50. **1.** ELEMENTS OF AGRICULTURAL ECONOMICS.—For Juniors, Seniors may elect. This course is designed to follow the required work in the elements of economics. It deals with the economic principles underlying the welfare and prosperity of the farmer and those institutions upon which his economic success depends; the economic elements in the production and distribution of agricultural wealth; means of exchange; determination of price; problems of land tenure and land values; taxation of farm property; and the maintenance of the economic status of the farmer. Lectures, text, readings, topics and field work.
5 class hours. Credit 5.
Professor CANCE.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

51. **1.** HISTORICAL AND COMPARATIVE AGRICULTURE.—For Juniors, Seniors may elect. Recommended to students in journalism or education. A general survey of agriculture, ancient and modern; feudal and early English husbandry; the later development of English agriculture; the course of agriculture in the United States, with special emphasis on the development of agriculture in New England. An attempt will be made to measure the influence of times, peoples and countries in producing different systems of agriculture, and to ascertain the causes now working to effect agricultural changes. Lectures, readings and library work.
5 class hours. Credit 5.
MR. STRAND.

52. **2.** CO-OPERATION IN AGRICULTURE.—For Juniors, Seniors may elect. The course treats of the history, principles and business relations of agricultural co-operation. (1) A survey of the development, methods and economic results of farmers' organizations and great co-operative movements; (2) the business organization of agriculture abroad, and the present aspects and tendencies in the United States; (3) the principles underlying successful co-operative endeavor among farmers, and practical working plans for co-operative associations, with particular reference to credit and purchase and the marketing of perishable products. Lectures, text, assigned readings and practical exercises.
5 class hours. Credit 5.
Professor CANCE.

75. **1.** THE AGRICULTURAL MARKET.—For Seniors and Graduate Students, Juniors may elect. A study of the forces and conditions which determine the prices of farm products, and the mechanism, methods and problems concerned with transporting, storing and distributing them. Supply and demand, course of prices, terminal facilities, the middleman system, speculation in agricultural products, protective legislation, the retail market and direct sales are taken up. The characteristics and possibilities of the New England market are given special attention. Lectures, readings, assigned studies and field work.
5 class hours. Credit 5.
Professor CANCE.

76. **2.** TRANSPORTATION OF AGRICULTURAL PRODUCTS.—For Seniors and Graduate Students, Juniors may elect. This course will sketch the development of the transportation in the United States, covering highways, waterways, railways and electric ways with reference to the facilities for and cost of transporting farm products, opening up new agricultural areas or industries, and contributing to the wealth and welfare of the agricultural population. Lectures, text and field work.
5 class hours. Credit 5.
Professor CANCE.

77. **3.** PROBLEMS IN AGRICULTURAL ECONOMICS.—For Seniors and Graduate Students, Juniors may elect. An advanced course for students desirous of studying more intensively some of the economic problems affecting

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

the farmer. Some of these are: land problems—land tenure, size of farms, causes affecting land values, private property in land, taxation of farm property; special problems—cost of producing farm products, farm labor in New England, immigration, agricultural credit. Opportunity will be given, if practicable, for field work, and students will be encouraged to pursue lines of individual interest.
5 class hours. Credit 5.
Professor CANCE.

80. **1.** SEMINAR.—For Seniors and Graduate Students. Research in agricultural economics and history; New England agriculture to 1860. Library work and reports. If desirable some other topic may be substituted. Hours to be arranged.
1 2-hour laboratory period, credit 1.
Professor CANCE.

81. **2.** SEMINAR.—For Seniors and Graduate Students. As stated in Course 80.
1 2-hour laboratory period, credit 1.
Professor CANCE.

82. **3.** SEMINAR.—For Seniors and Graduate Students. As stated in Course 80.
1 2-hour laboratory period, credit 1.
Professor CANCE.

AGRICULTURAL EDUCATION.

Professor HART.

Elective Courses.

50. **1.** MEANING OF EDUCATION (PSYCHOLOGY).—For Juniors, Seniors may elect. For teachers and others desiring an introduction to mental science. A study of the development, structure and functions of the nervous system and the sense organs; the development and nature of mental activities; the nature of the learning processes.
5 class hours. Credit 5.
Professor HART.

51. **2.** RURAL SCHOOL PROBLEMS.—For Juniors, Seniors may elect. Primarily for teachers. A study of agricultural education; the theory and practice of teaching; rural school organization; methods of instruction; the place and function of agriculture in the course of study for both rural and city schools; planning and practical work in school and home gardens; planning of equipment and ornamentation of rural school grounds.
2 class hours. 3 2-hour laboratory periods, credit 5.
Professor HART.

52. **4.** RURAL SCHOOL PROBLEMS.—For Juniors, Seniors may elect. As stated under Course 51.
120 laboratory hours, credit 5.
Professor HART.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

53. **3.** HISTORY AND PHILOSOPHY OF EDUCATION.—For Juniors, Seniors may elect. For teachers and others desiring an introduction to educational theories. A study of educational ideals and movements as exemplified by leading nations and races; the growth of educational institutions as influenced by science and industry; the history and meaning of industrial and agricultural education.
5 class hours. Credit 5.
Professor Hart.

75. **1.** PROBLEMS IN RURAL EDUCATION.—For Seniors, Juniors may elect. For teachers or others interested in special phases of education, such as child development, physical and mental; school organization; rural schools; secondary schools; school programs; grading and promotion of pupils; school grounds and school architecture and equipment; normal schools and the preparation of teachers; agricultural teaching and agricultural schools.
4 class hours. Credit 4.
Professor Hart.

76. **2.** PROBLEMS IN RURAL EDUCATION.—Seniors. As stated under Course 75.
4 class hours. Credit 4.
Professor Hart.

77. **2.** EXTENSION AND COUNTY AGENT WORK.—For Seniors, Juniors may elect. The course consists chiefly of library research work. Each student will be required to produce one or more complete lectures under guidance both as to method of preparation and subject-matter, and one or more demonstrations. These lectures will be presented to public audiences in the presence of a board of critics. Some instruction will be given in organization and administration of the Extension Service. The Extension Service will be responsible for the public presentation and criticism. The student's major adviser will be responsible for the accuracy of the subject-matter. The Department of Agricultural Education will be responsible for the preparation of the lectures.
3 class hours. 2 2-hour laboratory periods, credit 5.
Professor Hart.

78. **3.** EXTENSION AND COUNTY AGENT WORK.—For Seniors, Juniors may elect. As stated under Course 77.
3 class hours. 2 2-hour laboratory periods, credit 5.
Professor Hart.

RURAL SOCIOLOGY.

Professor Phelan, President Butterfield, Professor Hart, Mr. Lund, Mr. Baird.

Required Course.

27. **3.** ELEMENTS OF RURAL SOCIOLOGY.—Sophomores. A broad survey of the field of rural sociology, including such topics as the origin of rural

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Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

sociology, its methods and problems; relation of sociological to the scientific and technical aspects of agricultural problems; the development of the rural community in New England and the west, religious, educational and social ideals of rural people; characteristics and influence of the rural environment, the movement of the rural population, the effects of immigration; rural institutions, the school, the church, local government, effects of modern conditions of life on rural institutions; rural organization; problems of progress, an analysis of the needs of rural life in its further development. Lectures, readings and essays on assigned topics.
3 class hours. Credit 3.
Professor PHELAN.

Elective Courses.

50. **1.** SOCIAL CONDITION OF RURAL PEOPLE.—For Juniors, Seniors may elect. (A). The rural status; composition of the rural population, nature, extent, and causes of diseases and accidents, health agencies of control; extent and causes of rural delinquency and dependency, conditions of temperance of sexual morality and family integrity; child labor, women's work and position; standard of living, size of family; cultural ideals; community consciousness and activity; standards of business conduct and of political ethics.

(B). Rural Social Psychology: Characteristics of the rural mind, character of hereditary and environmental influence; nature and effect of face to face groups; fashion, conventionality, custom, character of discussion, and of public opinion.
3 class hours. Credit 3.
Professor PHELAN.

51. **2.** RURAL GOVERNMENT.—For Juniors, Seniors may elect. A general survey of the development of rural government in the United States; origin of the New England town, its influence upon the west, advantages, development of efficiency, county government, the influence of the farmer in legislation, good roads movement, credit, facilities, taxation, boards of agriculture, agricultural colleges and experiment stations in relation to rural welfare; national government; a general survey of political organizations and movements among farmers in the United States and foreign countries and their influence in shaping legislation; relation of the Department of Agriculture, postal system, the various national commissions and agencies to rural welfare. Lectures, readings, written exercises on assigned topics.
3 class hours. Credit 3.
Professor PHELAN.

52. **3.** RURAL ORGANIZATION.—For Juniors, Seniors may elect. A study of the organized agencies by which rural communities carry on their various forms of associated life, particularly a study of the ways by which the domestic, economic, cultural, religious and political institutions contribute to rural betterment; principles underlying leadership, qualifications of the paid leader and the

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Heavy faced type indicates the term in which the course is given.
Numbering of Courses:
1 to 24 inclusive Freshmen 50 to 74 inclusive Juniors
25 to 49 " Sophomores 75 to 99 " Seniors

lay leader; the field of rural social service, national, State and local, preparation and opportunity for service; rural community building, a study of organized ways and means by which aid is given local communities.
3 class hours. Credit 3.
President BUTTERFIELD.

75. **1 and 3.** FARMERS' ORGANIZATIONS.—For Seniors, Juniors may elect. The history, purposes and achievements of the Grange, the Farmers' Union, farmers' clubs, village improvement associations, boys' clubs, etc.; the method, scope and history of local, State and national associations formed about some farm product, their influence in forming class consciousness and in shaping agrarian legislation; need of federation. Lectures, readings and essays on assigned topics.
3 class hours. Credit 3.
Professor PHELAN.

76. **1.** FIELD WORK IN RURAL SOCIOLOGY.—For Seniors, Juniors may elect. This course is designed to meet the needs of students who wish to do some constructive work in rural social service while still in college. The work will be carried on in co-operation with the various college agencies engaged in rural service. Any project for which credit in this course is to be asked must first have the approval of the head of the department.
From 2 to 6 laboratory hours, credit 1 to 3.
Professor PHELAN.
Prerequisites, Rural Sociology 27 and 52.

77. **2.** RURAL SOCIAL SURVEYS.—For Seniors, Juniors may elect. A careful study of the theory and function of statistics, the limitations and difficulties in the use of statistics, the interpretation of statistical data, various methods of graphic representation; a study of surveys, kinds and use, method of gaining information, the basis for conclusions, value of information gained. Text and lectures.
3 class hours. Credit 3.
Professor PHELAN.

78. **2.** RURAL AND BUSINESS LAW.—For Seniors, Juniors may elect. The work of this course will cover such points as land, titles, public roads, rights incident to ownership of live stock, contracts, commercial paper and distinctions between personal and real property. Text, written exercises, lectures and class discussions.
5 class hours. Credit 5.
Professor HART.

79. **1** SEMINAR.

Credit 1 to 3.
Professor PHELAN.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

80. **2** SEMINAR.

Credit 1 to 3.
Professor Phelan.

81. **3** SEMINAR.

Credit 1 to 3.
Professor Phelan.

GENERAL DEPARTMENTS.

Military Science and Tactics.

First Lieutenant H. W. Fleet, 19th Infantry, U. S. A.; Assistant: Ordnance Sergeant J. J. Lee, U. S. A., retired; Adjutant Assistant: Quartermaster Sergeant Alex. Smart, U. S. A., retired.

(The Department of Military Science and Tactics conducts its work in conjunction with the Department of Physical Education and Hygiene, in accordance with the following statement:—

All candidates for a degree in a four-year course must take for three years three full hours a week of physical training. This work must be under college supervision. At least two years of the work must be taken in the Department of Military Science and Tactics, in accordance with the requirements of the War Department; the rest is to be taken in the Department of Physical Education.

Under this arrangement, the practical courses (drill) in military science are given in the first and third terms; the corresponding courses in physical education in the second term.

Under act of Congress (July 2, 1862), military instruction under a regular army officer is required in this college of all able-bodied male students. Men are excused from the exercises of this department only upon presentation of a certificate given by the college physician; minor disabilities which might bar enlistment are not considered. Students excused from military duty may be required to take equivalent work. The object of the instruction is to disseminate military knowledge in order that in emergency trained men may be found to command volunteer troops; but a further object is to give physical exercise, to teach obedience without detracting from self-respect, and to develop the bearing and courtesy that are as becoming in a citizen as in a soldier. Absences and other offenses of military nature, and those of which the military instructor may take cognizance as affecting discipline, are dealt with by the commandant in accordance with the regulations of the department; but delinquencies in theoretical instruction not strictly military in their nature are dealt with in accordance with the rules of the faculty.

Cadets in the graduating class who have shown special aptitude for military service are reported to the Adjutant-General of the United States army and to the Adjutant-General of Massachusetts; in making appointments from civil life to the regular or volunteer army, preference is given to those who have been so reported. The names of the three most distinguished are published in the "Official Register of the United States Army." Assignments to the band are made by the military instructor. Practice in the band is credited in place of drill and theoretical instruction.

The required uniform is of olive drab cloth, costing about $17. It is worn by all cadets when on military duty, and may be worn at other times. The uniforms are procured through an authorized tailor. Students upon entering college are required to deposit $17 with the college treasurer to cover the cost of the uniform. The sale of old uniforms is prohibited, unless the consent of the military instructor be obtained.)

Required Courses.

1. **1.** TACTICS.—Freshmen. Theoretical instruction in infantry drill regulations through the battalion and ceremonies. Lectures on military subjects and military history.

1 class hour. Credit 1.
Lieutenant Fleet.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

3. **3.** TACTICS.—Freshmen. As stated under Course 1.
1 class hour. Credit 1.
Lieutenant Fleet.

4. **1.** DRILL.—Freshmen. Practical instruction in infantry drill regulations through the battalion. Ceremonies.
3 laboratory hours, credit 1.
Lieutenant Fleet.

6. **3.** DRILL.—Freshmen. As stated under Course 4. Company training in bayonet exercises and physical exercises with and without arms.
3 laboratory hours, credit 1.
Lieutenant Fleet.

25. **1.** TACTICS.—Sophomores. Theoretical instruction in map problems in security and information. Combat. Lectures on military subjects and military history.
1 class hour. Credit 1.
Lieutenant Fleet.

27. **3.** TACTICS.—Sophomores. As stated under Course 25.
1 class hour. Credit 1.
Lieutenant Fleet.

28. **1.** DRILL.—Sophomores. Practical instruction in field service regulations in the service of security and information. Corporals are appointed from this class.
3 laboratory hours, credit 1.
Lieutenant Fleet.

30. **3.** DRILL.—Sophomores. As stated under Course 28: intrenching, combat.
3 laboratory hours, credit 1.
Lieutenant Fleet.

50. **1.** MILITARY SCIENCE.—Juniors. Theoretical instruction in the small arms firing regulations, in fire discipline, fire control and fire direction.
1 class hour. Credit 1.
Lieutenant Fleet.

52. **3.** MILITARY SCIENCE.—Juniors. As stated in Course 50.
1 class hour. Credit 1.
Lieutenant Fleet.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

53. **1.** DRILL.—Juniors. Practical instruction in the small arms firing regulations in target practice, estimating distances and field firing. Lieutenants and sergeants are appointed from this class.

3 laboratory hours, credit 1.
Lieutenant FLEET.

55. **3.** DRILL.—Juniors. As stated under Course 53.

3 laboratory hours, credit 1.
Lieutenant FLEET.

Elective Courses.

75. **1.** MILITARY SCIENCE.—Seniors. Theoretical instruction in Infantry drill regulations, field service regulations, and small arms firing regulations for company, battalion and regiment.

1 class hour. Credit 1.
Lieutenant FLEET.

77. **3.** MILITARY SCIENCE.—Seniors. As stated under Course 75.

1 class hour. Credit 1.
Lieutenant FLEET.

78. **1.** DRILL.—Seniors. Conduct drills of lower classes. Field officers and captains are appointed from this class. These officers are paid. The positions in every case are obtained by competition. It is to be understood that cadets obtaining these positions will be reported to the Adjutant-General of the army as distinguished cadets.

3 laboratory hours, credit 1.
Lieutenant FLEET.

80. **3.** DRILL.—Seniors. As stated under Course 78.

3 laboratory hours, credit 1.
Lieutenant FLEET.

PHYSICAL EDUCATION AND HYGIENE.

Associate Professor HICKS, MR. GORE, MR. FITZMAURICE.

PHYSICAL EDUCATION.

(The Department of Physical Education conducts its work in physical training in conjunction with the Department of Military Science and Tactics, as explained in the note preceding the description of the courses in military science. All classified undergraduate students are given a physical examination upon entering).

Required Courses.

1. **1.** HYGIENE.—Freshmen. Lectures, reading, quizzes and a report on some assigned topic of personal hygiene or sanitation.

1 class hour. Credit 1.
Associate Professor HICKS.

Heavy faced type indicates the term in which the course is given.

Numbering of Courses:

1 to 24	inclusive	Freshmen	50 to 74	inclusive	Juniors
25 to 49	"	Sophomores	75 to 99	"	Seniors

5. **2.** ELEMENTARY GYMNASTICS.—Freshmen. Exercises, games and athletics.

3 laboratory hours, credit 1.
MR. GORE and MR. FITZMAURICE.

26. **2.** GRADED GYMNASTICS.—Sophomores. Exercises, games and athletics.

3 laboratory hours, credit 1.
MR. GORE and MR. FITZMAURICE.

51. **2.** GYMNASTICS.—Juniors. Drills, games and athletics.
3 laboratory hours, credit 1.
MR. GORE and MR. FITZMAURICE.

Elective Course.

77. **3.** TRAINING COURSE.—Seniors. History of physical education; supervision of indoor and outdoor athletic contests and games; athletic administration.
1 class hour. Credit 1.
Associate Professor HICKS.

Heavy faced type indicates the term in which the course is given.
Numbering of Courses:

1 to 24 inclusive	Freshmen	50 to 74 inclusive	Juniors
25 to 49 "	Sophomores	75 to 99 "	Seniors

Public Document No. 31

TWENTY-EIGHTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PARTS I. AND II.,

Being Parts III. and IV. of the Fifty-third Annual Report of the Massachusetts Agricultural College.

January, 1916.

Ending the Thirty-third Year from the Founding of the State Agricultural Experiment Station.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1916.

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TWENTY-EIGHTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PARTS I. AND II.,

BEING PARTS III. AND IV. OF THE FIFTY-THIRD ANNUAL REPORT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1916.

ENDING THE THIRTY-THIRD YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
32 DERNE STREET.
1916.

APPROVED BY
THE STATE BOARD OF PUBLICATION.

TWENTY-EIGHTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

PART I.

REPORT OF THE DIRECTOR AND OTHER OFFICERS.

PART II.

DETAILED REPORT OF THE EXPERIMENT STATION.

A RECORD OF THE THIRTY-THIRD YEAR FROM THE FOUNDING OF THE STATE AGRICULTURAL EXPERIMENT STATION.

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Massachusetts Agricultural Experiment Station.

OFFICERS AND STAFF.

COMMITTEE.

Trustees.	Charles H. Preston, *Chairman*,	Hathorne.
	Wilfrid Wheeler,	Concord.
	Edmund Mortimer,	Grafton.
	Arthur G. Pollard,	Lowell.
	Harold L. Frost,	Arlington.

The President of the College, *ex officio*.
The Director of the Station, *ex officio*.

STATION STAFF.

Administration.

William P. Brooks, Ph.D., *Director*.
Joseph B. Lindsey, Ph.D., *Vice-Director*.
Fred C. Kenney, *Treasurer*.
Charles R. Green, B.Agr., *Librarian*.
Mrs. Lucia G. Church, *Clerk*.
Miss F. Ethel Felton, A.B., *Clerk*.

Agricultural Economics.

Alexander E. Cance, Ph.D., *Agricultural Economist*.

Agriculture.

William P. Brooks, Ph.D., *Agriculturist*.
Henry J. Franklin, Ph.D., *In Charge Cranberry Substation*.
Edwin F. Gaskill, B.Sc., *Assistant Agriculturist*.
Robert L. Coffin, *Assistant*.

Chemistry.

Joseph B. Lindsey, Ph.D., *Chemist*.
Edward B. Holland, Ph.D., *Associate Chemist in Charge (Research Section)*.
Fred W. Morse, M.Sc., *Research Chemist*.
Henri D. Haskins, B.Sc., *Chemist in Charge (Fertilizer Section)*.
Philip H. Smith, M.Sc., *Chemist in Charge (Feed and Dairy Section)*.
Lewell S. Walker, B.Sc., *Assistant Chemist*.
Rudolf W. Ruprecht,[1] M.Sc., *Assistant Chemist*.
Carleton P. Jones, M.Sc., *Assistant Chemist*.
Carlos L. Beals, B.Sc., *Assistant Chemist*.
James P. Buckley, Jr., *Assistant Chemist*.
Norman H. Borden, B.Sc., *Assistant Chemist*.
James T. Howard, *Inspector*.
Harry L. Allen, *Assistant in Laboratory*.
James R. Alcock, *Assistant in Animal Nutrition*.
Miss Alice M. Howard, *Clerk*.
Miss Rebecca L. Mellor, *Clerk*.

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[1] On leave.

Entomology.	Henry T. Fernald, Ph.D., *Entomologist.* Burton N. Gates, Ph.D., *Apiarist.* Arthur I. Bourne, A.B., *Assistant Entomologist.* S. C. Vinal, B.Sc., *Graduate Assistant.* Miss Bridie E. O'Donnell, *Clerk.*
Horticulture.	Frank A. Waugh, M.Sc., *Horticulturist.* Fred C. Sears, M.Sc., *Pomologist.* Jacob K. Shaw, Ph.D., *Research Pomologist.* Harold F. Tompson, B.Sc., *Market Gardener.* R. P. Armstrong, M.Sc., *Graduate Assistant.* Miss Gladys E. Russell, A.B., *Clerk.*
Meteorology.	John E. Ostrander, A.M., C.E., *Meteorologist.* David Potter, *Observer.*
Microbiology.	Charles E. Marshall, Ph.D., *Microbiologist.* F. H. Hesselink van Suchtelen, Ph.D., *Research Microbiologist.*
Poultry Husbandry.	John C. Graham, B.Sc., *Poultry Husbandman.* Hubert D. Goodale, Ph.D., *Research Biologist.* Donald White, B.A., *Graduate Assistant.* Miss Marcella C. Curry, B.Sc., *Clerk.*
Vegetable Physiology and Pathology.	George E. Stone,[1] Ph.D., *Vegetable Physiologist and Pathologist.* A. Vincent Osmun,[2] M.Sc., *Associate Vegetable Pathologist.* George H. Chapman, M.Sc., *Research Vegetable Physiologist.* Orton L. Clark, B.Sc., *Assistant Vegetable Physiologist and Pathologist.* Miss Jessie V. Crocker, *Clerk.*
Veterinary Science.	James B. Paige, B.Sc., D.V.S., *Veterinarian.* G. Edward Gage, Ph.D., *Research Pathologist.* Miss Beryl H. Paige, A.B., *Assistant.* Arnold B. Sturtevant, A.B., *Assistant.*

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[1] On account of ill health not in administrative charge.

[2] In administrative charge.

REPORT OF THE DIRECTOR.

WM. P. BROOKS.

ADMINISTRATION.

Station Staff.

Although some loss in experience and efficiency has been occasioned during the past year by changes in staff due to resignations, usually to accept positions offering better salaries, these have affected only assistantships, and the year has, on the whole, been marked by progress. No major positions have been vacated, and Dr. George E. Stone, research plant physiologist, who had been obliged to take leave of absence on account of ill health, was able to take up investigational work again in October. He is not to resume administrative charge of the department of botany.

The staff has been materially strengthened by additions and transfers, the new men in a number of instances having undertaken altogether new lines of investigation. The nature of the changes which have taken place is shown by the following statement: —

Resignations.

Walter S. Frost, B.Sc., Assistant Chemist.
Norman H. Borden, B.Sc., Assistant Chemist.
Grace E. Gallond, Stenographer, Administration Department.
R. E. McLain, Observer.

Appointments.

Robert L. Coffin, Assistant, Agricultural Department.
Beryl H. Paige, A.B., Assistant Animal Pathologist, Veterinary Department.
Arnold P. Sturtevant, A.B., Assistant Animal Pathologist, Veterinary Department.
Norman H. Borden, Assistant Chemist.
Charles W. Davis, Assistant Chemist.
R. P. Armstrong, M.Sc., Graduate Assistant, Pomology Department.
Donald White, B.A., Graduate Assistant, Poultry Husbandry Department.

S. C. Vinal, B.Sc., Graduate Assistant, Entomology Department.

E. G. Hood, B.Sc., Industrial Graduate Assistant, Microbiology Department.

W. T. Payne, B.Sc., Industrial Graduate Assistant, Microbiology Department.

Marcella C. Curry, B.Sc., Clerk, Poultry Husbandry Department.

F. Ethel Felton, A.B., Clerk, Administration Department.

David Potter, Observer.

From Instructional Staff for Part-time Duty.

F. H. Van Suchtelen, Ph.D., Research Microbiologist.

G. E. Gage, Ph.D., Research Pathologist.

H. F. Tompson, B.Sc., Market Gardener.

Gladys E. Russell, A.B., Clerk, Horticultural Department.

Leaves of Absence.

R. W. Ruprecht, M.Sc., Assistant Chemist, granted leave of absence without pay from Oct. 1, 1915, to June 30, 1916, for the purpose of pursuing advanced study at Cornell University.

J. B. Lindsey, Ph.D., Vice-Director, Chemist, allowed an extra month vacation with pay.

Bridie E. O'Donnell, Clerk, Entomology Department, granted one month leave of absence, without pay, on account of ill health. Her place was taken by Miss Mary Field from July 5 to September 4.

MAINTENANCE.

There has been no change during the past year in the sources of revenue supporting the various lines of work of the experiment station. The appropriation for general expenses from the State, in accordance with the provisions of the Acts of 1912, has been $5,000 greater than in the previous fiscal year. There has been a large increase in the receipts from the sales of fruit from the Graves' orchard. On the other hand, there has been a falling off of practically $1,000 in the receipts from analysis fees under the fertilizer law. This falling off has undoubtedly been due to the abnormal conditions created by the European war. These conditions have resulted in an embargo on exportation of potash from Germany. As there is at present no other adequate source of supply the result has been a considerable reduction in the number of brands of fertilizers offered in our markets.

The total revenues are shown in the following table: —

Total Revenue for the Fiscal Year, Dec. 1, 1914, to Nov. 30, 1915.

State appropriation,	$25,000 00
Federal appropriations: —	
Hatch fund,	15,000 00
Adams fund,	15,000 00
Agricultural department, sales and labor,	2,365 01
Chemical department, analytical work, cow testing, etc.,	10,690 39
Miscellaneous receipts from various departments,	226 68
Fertilizer law, analysis fees,	10,096 00
Feed law, State appropriation,	6,000 00
Cranberry substation: —	
Sale of fruit,	2,286 49
Meteorological observations, etc.,	141 67
Miscellaneous,	8 85
Graves' orchard: —	
Sale of fruit,	1,043 59
Total,	$87,858 68

The aggregate total revenue exceeds the aggregate for the last year to the amount of $5,432.75. The total required in the execution of the feed and fertilizer laws amounted to $15,384.79. These expenditures in detail are shown in subsequent pages. The total current revenue available for general administration and investigation, therefore, amounted to $72,473.89.

The treasurer's report in full will be found on pages 35*a* and 36*a*.

FERTILIZER LAW ACCOUNT, DEC. 1, 1914, TO NOV. 30, 1915.

Balance Dec. 1, 1914,	$2,853 70	
Fertilizer analysis fees,	10,096 00	
Total,		$12,949 70

Expenditures.

Salaries: —		
Chemical,	$5,827 92	
Clerical,	450 00	
		$6,277 92
Labor: —		
Miscellaneous,	$120 00	
Janitor,	201 98	
		321 98
Chemicals and apparatus,		600 98

Collection expenses: —			
Inspectors' salaries,	$621 00		
Inspectors' traveling expenses,	536 76		
		$1,157 76	
Office supplies,		189 70	
Laundry,		14 30	
Gas,		92 63	
Traveling expenses, miscellaneous,		36 80	
Library,		2 00	
Repairs,		8 88	
Miscellaneous,		128 28	
Publication: —			
Bulletin No. 2,	$706 58		
Mailing,	14 20		
		720 78	
Fertilizer experiments: —			
Labor and materials,	$470 00		
Rent of land,	25 00		
		495 00	
Total,			$10,047 01
Balance Dec. 1, 1915,			$2,902 69

FEED CONTROL ACCOUNT, DEC. 1, 1914, TO NOV. 30, 1915.

Balance Dec. 1, 1914,	$1,018 14	
Appropriation,	6,000 00	
Total,		$7,018 14

Expenditures.

Collection expenses: —			
Inspector's time,	$255 00		
Inspector's traveling expenses,	417 76		
		$672 76	
Salaries, chemical and clerical,		3,625 42	
Labor, janitor,		114 43	
Gas,		35 25	
Laboratory apparatus,		39 47	
Chemicals,		155 35	
Office supplies,		32 44	
Traveling expenses, miscellaneous,		48 24	
Repairs,		22 27	
Sundries,		61 77	
Library,		10 00	
Publication: —			
Bulletin No. 3,		520 38	
Total,			5,337 78
Balance Dec. 1, 1915,			$1,680 36

Publication.

There has been no change during the past year in the general policy affecting publication. The change in plan of printing described in the twenty-seventh annual report continues to prove highly satisfactory. It has resulted in an important reduction in expenditure, and it has made possible a much more prompt and satisfactory distribution of the papers issued. The following list includes both the publications of the past year and a few earlier issues not previously mentioned in reports: —

Annual Report.

Twenty-seventh annual report: —
Part I. Report of the Director and Other Officers; 69 pages.
Part II. Detailed Report of the Experiment Station; 167 pages; being bulletins Nos. 156–162, as follows: —
No. 156. Electrical Injuries to Trees, by G. E. Stone; 24 pages.
No. 157. The Marguerite Fly or Chrysanthemum Leaf Miner, by M. T. Smulyan; 36 pages.
No. 158. The Composition, Digestibility and Feeding Value of Molassine Meal, Cottonseed Meal and Hulls, Cocoa Shells, Grain Screenings, Flax Shives, Mellen's Food Refuse, and Postum Cereal Residue (CXX Feed), by J. B. Lindsey and P. H. Smith; 24 pages.
No. 159. The Technical Description of Apples, by J. K. Shaw; 24 pages.
No. 160. Report of Cranberry Substation for 1914, by H. J. Franklin; 32 pages.
No. 161. The Effect on a Crop of Clover of liming the Soil, by F. W. Morse; Toxic Effect of Iron and Aluminum Salts on Clover Seedlings, by R. W. Ruprecht; 16 pages.
No. 162. Phosphates in Massachusetts Agriculture: Importance, Selection and Use, by Wm. P. Brooks; 44 pages.
Combined Contents and Index, Parts I. and II.; 12 pages.

Bulletins.

No. 163. Bacillary White Diarrhea (*Bacterium Pullorum* Infection) in Young Chicks in Massachusetts, by G. Edward Gage and Beryl H. Paige; 48 pages.
No. 164. I. Substitutes for Milk in the Rearing of Dairy Calves. II. The Cost of rearing a Dairy Cow, by J. B. Lindsey; 23 pages.
No. 165. The Effect of Sulfate of Ammonia on Soil, by R. W. Ruprecht and F. W. Morse; 19 pages.

No. 166. Improved Methods for Fat Analysis, by E. B. Holland, J. C. Reed and J. B. Buckley, Jr.; 48 pages.

No. 167. I. The Relation of Hydrogen Ion Concentration of Media to the Proteolytic Activity of Bacillus Subtilis. II. Proteolysis of *Streptococcus Erysipelatis* and *Streptococcus Lacticus* under Different Hydrogen Ion Concentration, by Arao Itano; 47 pages.

Control Series Bulletin No. 3. Inspection of Commercial Feedstuffs, by P. H. Smith and C. L. Beals; 70 pages.

Control Series Bulletin No. 4. Inspection of Commercial Fertilizers, by H. D. Haskins, L. S. Walker, C. P. Jones and W. S. Frost; 100 pages.

Circulars.

No. 48. Beet Residues for Farm Stock, by J. B. Lindsey; 8 pages.

No. 49. Cabbage, Cauliflower, Turnip, Rape and Other Crucifers, by Wm. P. Brooks; 4 pages.

No. 50. Rations for Dairy Stock, by J. B. Lindsey; 8 pages.

No. 51. Downy Mildew of Cucumbers, by G. E. Stone; 2 pages.

No. 52. The Control of Onion Smut, by G. E. Stone; 4 pages.

No. 53. Lime and Sulfur Solutions, by G. E. Stone; 2 pages.

No. 54. Poultry Manures, their Treatment and Use, by Wm. P. Brooks; 4 pages.

No. 55. Green Manuring and Cover Crops, by Wm. P. Brooks; 6 pages.

No. 56. Campaign to eliminate Bacillary White Diarrhea, by Wm. P. Brooks and E. D. Waid; 1 page.

No. 57. Rules relative to testing Dairy Cows, by P. H. Smith; 4 pages.

No. 58. The Feeding Value of Apple Pomace, by J. B. Lindsey; 4 pages.

Meteorological Reports.

Twelve numbers, 4 pages each.

The total number of copies of general reports and bulletins issued during the last fiscal year was 95,100. In addition, 5,400 meteorological bulletins were printed and 19,000 copies of circulars, making a grand total of 119,500 copies of publications issued during the year.

MAILING LISTS.

The mailing lists which we maintain and the numbers in the several lists are shown in the following table: —

Residents of Massachusetts (general),	12,237
Residents of other States (general),	953
Residents of other States (general and technical),	1,333
Exchange,	212
Beekeepers,	4,147
Newspapers,	507
Cranberry,	1,602
Meteorological,	393
Feed,	671
Fertilizer,	54
Greenhouse vegetable growers,	1,850
Onion growers,	107
Massachusetts florists,	1,100
Miscellaneous special lists,	107
Massachusetts libraries,	187
Out of State libraries,	212
United States Department of Agriculture, official list,[1]	3,627
Total,	29,299[2]

During the year there has been a total increase of 967 addresses, — about 3 per cent.

THE NEEDS OF THE STATION.

Particular attention was called in my last annual report to three pressing needs: additional land, provision for work in more direct and closer touch with the market-garden interests of the State, and an appropriation for experimental demonstrations in various localities.

Additional Land. — The first need has been in part met by the lease for a term of seven years, with the option of purchase any time before the end of that period, of a farm containing rather over seventy acres, about half of which is improved land and the balance unimproved pasture. This farm, though not contiguous to the areas now used in our station work, is sufficiently near to be fairly accessible, and while it exhibits considerable variation in topography and character of soil, it is very typical of Massachusetts conditions and possesses several tracts sufficiently uniform to permit of subdivision into plots which will be fairly adapted to our needs. The unimproved pasture will afford opportunity for needed investigation in methods of pasture treatment and improvement.

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[1] Publications are not as a rule sent to all on this list, but only to directors, libraries and specialists likely to be interested.

[2] Of this total, under different lists are included 261 foreign addresses.

The option on this property should most certainly be closed, both because the land which it covers is the best suited to our needs of anything within reasonable distance which can be purchased, and because at the same time it is offered to the State at a figure which is not above its value in the open market.

For the purpose especially of accommodating growing stock needed in our experimental work with poultry we should have another tract of land at the earliest possible date. Looking forward to the not distant future it is clearly apparent that in the work of the poultry department some fifty to sixty acres will be needed. The reasons why it is, practically speaking, impossible to raise healthy stock in large numbers upon the limited area at present available were stated in my last report and it is unnecessary to repeat. It was found necessary last season to lease a few acres of land to meet the most pressing need, and the rent paid on the best terms that could be obtained was far higher than we should be justified in continuing permanently to pay. The need of the poultry department for more land should certainly be provided for in the near future.

The Market-gardening Interests. — Fuller provision for experiments in the direct interests of the market gardeners of the State was urged in my last annual report. The position taken was that the employment of a man thoroughly familiar with the industry and its requirements, a good observer, one quick to detect abnormal crop conditions, and competent, at least in case of many of the more common partial or complete crop failures, to determine the causes, who should refer to the scientific staff in the home laboratories such matters and materials as needed scientific investigation, would fairly meet the most pressing needs.

It has been made possible during the past year to meet this need in part through the co-operation of the Boston Market Gardeners' Association, the United States Department of Agriculture, the Massachusetts Agricultural College and the Experiment Station, which together provide the funds necessary to pay the salary of Mr. H. F. Tompson, in whose thorough competence the work he has already done justifies the fullest confidence. Mr. Tompson spends a large share of his time among the growers in the Boston market-garden district. His activities thus far are more largely of the nature of extension than experiment, but his close touch with the market-garden industry has enabled him to indicate lines of investigation which seem to me most greatly needed, and one of these, through the assignment thereto of a promising graduate student who has been given an assistantship, has already been taken up.

Another result of Mr. Tompson's work with and for the market gardeners has been that their interest and belief in the possibilities of scientific investigation and practical experiment have been greatly stimulated. As a result the Boston Market Gardeners' Association has presented to the Legislature now in session a petition for the enactment of a bill providing, first, an appropriation of $20,000 for the purchase of land, the erection of buildings and the equipment of a market-garden experiment station, to be under the management and control of the trustees of the Massachusetts Agricultural College; and second, an annual appropriation of $10,000 for the support of such a station. The enactment of this bill would give means for the acquirement and support of a plant which should soon abundantly demonstrate the wisdom of the legislation asked for. The funds provided for the annual support should prove for the present fairly adequate to support both the experimental and demonstrational work at the market-garden station itself, and also the related scientific investigation of problems affecting the market-garden industry carried on in the central experiment station laboratories.

Experimental Demonstrations. — No direct provision for the support of these has yet been made, but the enactment of the bill establishing a market-garden station would go a long ways towards satisfying the need in a very important branch of our agriculture, for the bill provides for demonstration as well as for investigation, and the establishment of the station in a central and easily accessible location in the principal market-garden section of the State would bring its work within easy reach of the busy, practical man engaged in the industry, and this as well as trial under varied local conditions is one of the important objects in experimental demonstration.

Further, the rapid organization of the county leagues and the adoption in these leagues of a carefully considered plan for demonstrations under the supervision of the county agents, who work in close touch with the college and station, will also help. While, therefore, the line of work under consideration might undoubtedly be considerably extended with profitable results, it is perhaps the part of wisdom to allow opportunity for the fuller development of the two movements referred to before asking direct support of local experimental demonstrations.

Tobacco Growers' Problems. — The area of land in Massachusetts suited to the production of wrapper leaf tobacco is relatively small. The industry under normal conditions has been among the most profitable agricultural specialties in the State. Accordingly there has been a marked tendency to practice continuous culture upon the best tobacco soils. In many cases, though by no means invariably, the crops on such soils have been growing less and less satisfactory for a considerable number of years, until in extreme cases the crop is a practical failure. There has been for some years a growing feeling among tobacco growers that the station should carry on more experimental work with a view to helping solve their many problems. We have, it is true, had one of our most competent research men devote the greater part of his time for four or five years to the study of mosaic, which at the time the work was begun seemed to be the most serious disease affecting tobacco; our chemists have studied the composition of a large number of tobacco soils with a view to determining whether the condition known as "tobacco sickness" could be connected with the systems followed in the use of manures and fertilizers; and we have carried on a considerable number of other lines of experiment. Although we believe we have thrown some light upon it, we have not, however, solved the problem of greatest interest to growers, namely, how to correct or to prevent "tobacco sickness," how to grow tobacco crops satisfactorily both as to yield and quality, if not continuously at least a large proportion of the time, upon the same land.

The crop failures during the past year were more numerous and more disastrous than ever before, and although it is generally believed that the abnormal weather conditions were in controlling measure responsible for them in most cases, the situation has led tobacco growers to appeal to us for assistance to a degree never before experienced. Several widely signed petitions urging more investigation in the interest of tobacco growing have been received, and the growers on their own initiative have appealed to the Legislature for a special appropriation of $2,000 to the station in order that such investigations may be more extensively carried on. The importance of the industry and the seriousness of the situation now confronting it fully warrant such an appropriation, for without encroaching upon funds needed to carry on other and important lines of investigation already undertaken, there can be no great increase in the attention devoted to tobacco work until we have increased financial support.

Work for Private Individuals.

For a full statement of the policy of the station in regard to private work for individuals, the reader is referred to the twenty-sixth annual report. Attention, however, is once more called to the fact that the experiment station is organized and supported for work in the interest of the public. It is contrary to its policy to undertake work for individuals which has neither a general nor a public interest, and if such work seems for any special reason to be desirable, the station will undertake it only if its right to publish and discuss results be fully conceded. The station will not under any circumstances accept commercial work in the sole interest of the party applying for the same. An apparent exception is the sanitary analysis of drinking waters, for which there is a uniform charge of $3. This charge is made not with a view to recovering the cost of such analysis (it is hardly one-third the amount which a commercial chemist usually charges), but rather as a restraining influence. It seems to be necessary, in order to prevent the indiscriminate forward-ing of samples in such numbers as to constitute a serious burden, and in many cases under conditions not indicating the need of examination. The station determines fat and total solids in milk and cream and the lime requirement of soils without charge. It does the former in the interest of improvement in the quality of our dairy stock and improved dairy practice; the latter in the belief that a more general judicious use of lime will constitute a basis for much more satisfactory returns with most of our farm and garden crops.

CONTROL WORK.

The laws relative to control work affecting fertilizers, feeds and dairy apparatus have been executed as usual the past year. No feature of the work appears to call for special comment. The number of brands of commercial fertilizer offered for sale in the State during the past year was considerably less than in 1914. The number of samples taken and the amount of analytical work were about the same. Previous to 1915 there had been a well-defined tendency to increase the number of brands of fertilizers offered in our markets. The change referred to is a direct consequence of the conditions affecting the fertilizer market created by the European war. Potash salts have been obtainable only at prices practically prohibitive. The importation of basic slag meal has entirely ceased, while the prices of fertilizer materials in general have advanced sharply. The percentage of potash in nearly all standard brands of fertilizer has been greatly reduced by their manufacturers. Attention is once more called to the fact that the station has no authority in this matter. It is charged simply with the duty of taking such a number of samples and making so many analyses as will determine whether the goods offered by manufacturers contain substantially the quantities of the several plant food elements guaranteed.

In the case of commercial feeds, the tendency which has been apparent for some years to gradual increase in the number of brands of feeds offered for sale in our markets has continued. The number sampled last year was no less than 1,100. Certainly every feeder should be able to find something that meets his needs unless, indeed, the bewildering number so confuses him that he finds it difficult to make up his mind. Since, connected with the sale of most of these brands, there must be a certain amount of advertising, in most cases a certain number of traveling salesmen, and always a more or less expensive competition between the makers of the different kinds, the tendency under discussion is to be regretted, for the multiplication of brands must on the whole tend to an increase in the cost of feeds, since the buyer must ultimately pay all the costs.

The following table will be of interest: —

Number of Official Samples.

Year.	Fertilizers.		Feeds.	
	Brands.	Samples.	Brands.	Samples.
1909,	458	1,052	196	895
1910,	487	890	195	946
1911,	519	1,063	204	1,055
1912,	527	1,180	194	902
1913,	571	1,299	227	1,115
1914,	606	1,307	1,002	924
1915,	513	1,322	1,100	1,043

LINES OF INVESTIGATION.

Such changes as have occurred in lines of investigation in progress during the past year have been in the main incidental to the gradual increase in the scope and amount of the work in progress. Most of the old lines, in many cases, however, with modifications suggested by the progress of the investigation, are continued. The new lines of investigation begun during the past year are as follows: —

Adams Fund Projects.

Effect of Sulfate and Muriate of Potash on Soils of Fields A and B.
Lime Absorption and Acidity of Field A.
Investigation as to the Causation and Control of a Disease of Bees known as European Foul Brood.
Methods of Diagnosis of Bacillary White Diarrhea.
Broodiness in Poultry.

General Projects.

Microbiological Investigations in Milk.
Microbiological Investigations in Soils.
Experiments to determine Both the Mode of Inheritance of Various Characters of Poultry and a Study of Other Factors governing Form and Function, those at present being studied being Egg Production, Hatchability of Eggs, Plumage Color, Comb Form, Booting, Certain Growth Characteristics and Secondary Sexual Characters.
Effect of Liming Soil on Assimilation of Nitrogen by Crops.
The Local Balance of Trade in Farm Products.
Study of Agricultural Insurance in Massachusetts.
Methods and Costs of Distribution of Tobacco, Onions and Potatoes.

One new line of investigation has been begun during the past year which deserves special mention, namely, the testing of dairy machinery and apparatus with a view to determining its merits as judged by the strictest scientific tests at the expense of the manufacturers. This type of work has not yet been adopted as a general policy but is under trial with the De Laval Separator Company. This company meets all expenditures connected with this work. The details are looked after by graduate students who are classified as industrial graduate assistants. Three such assistants are now giving one-half their time to this investigation which, so far as can now be judged, promises to prove eminently satisfactory, not only to the De Laval Company but to the college and station as well, since the company freely grants to the station the privilege of perfect liberty in investigation and absolutely unbiased scientific discussion and publication.

THE ASPARAGUS SUBSTATION, CONCORD.

The work in the asparagus substation during the past year has been conducted along the same lines as heretofore. The breeding work has been in local charge of Prof. J. B. Norton, who has looked after it ever since it was begun in 1906. Mr. Norton's work has been characterized by great enthusiasm, indefatigable industry and a high degree of originality and skill. It is our belief that he has produced a number of strains of asparagus possessing at the same time excellent commercial characteristics and in very high degree the capacity to resist attacks of rust. Roots and seed of some of these strains of rust-resistant asparagus have been produced in sufficient quantity to allow a considerable distribution in the spring of 1915. The experiment station placed in the hands of 99 different individuals either roots or seed, or both, as follows: 68 lots of roots of 50 each, and 217 ounce packets of seed. The individuals sharing in this distribution agreed to make careful observations and to report results. It is, of course, as yet too early to have thoroughly tested the new stock, but reports were called for at the end of the last season, and these, in general, are very favorable. Unfortunately, 1915, as regards testing capacity to resist rust, was not in most localities characterized by general and virulent attacks, but a considerable number of the parties testing the new stock reported it less affected by rust than other varieties under cultivation. There will be an additional supply of roots and seed for distribution next spring, and within a few years it will be possible to accumulate data which will show clearly whether the new varieties will prove permanently and generally valuable.

The details of the work connected with the investigation as to the plant food requirements of the crop have been looked after by Mr. C. W. Prescott with his usual faithful attention. The total yield of the plots during 1915 was not quite as great as in the previous year. The average per acre, however, was at the rate of 7,314 pounds, while the yield of the best plot was at the rate of 8,679 pounds per acre. Six plots (1/20 acre each) gave a yield at rates exceeding 8,000 pounds per acre. There was relatively little rust in the asparagus districts in Concord in 1915. The small reduction in yield as compared with 1914 is easily accounted for by the excessive drought which prevailed during the cutting season.

There has been little rust on asparagus of any kind in Concord during the past three years. Conditions have been such that the crop has indicated the full, normal effect of the different fertilizers and fertilizer combinations used. Under such weather conditions as have prevailed, and since the weather conditions have not been to any considerable extent abnormal, with the exception perhaps of the drought of 1915, it is believed that the crops obtained on the different plots must now afford a pretty clear index to the relative values of the different materials and combinations applied. That this is the case is still further indicated by the fact that the results during the past three years in general have shown close agreement. It would seem, therefore, that the main objects in view when the experiment was planned have been realized, and for this reason chiefly it has been decided to discontinue this branch of our work in Concord. A similar line of experiments in progress in Amherst will, however, be continued. A full account of the experiments and a report on the results obtained both in the field and in the investigations connected therewith in the chemical laboratory will be published later as a bulletin. The following brief account and summary of results and conclusions will be of interest: —

The fertilizer experiments were planned with a view to obtaining answers to certain definite questions. Among these questions several of the most important relate to the use of nitrate of soda. These questions are as follows:

1. What amount of nitrate of soda, if any, can profitably be used in connection with a liberal application of fertilizers supplying phosphoric acid and potash? The nitrate has been applied in three different amounts in each of four different sets of plots. These amounts are at the following rates per acre: 300, 450 and 600 pounds.

The results from year to year and in the different sets of plots have not been strictly concordant. Nitrate of soda, however, has not failed in any combination to produce a large increase in the crop. In a considerable number of instances, the minimum application, 300 pounds per acre, has given as large an increase as any larger quantity, but a study of the yields and of the conditions affecting all plots leads me to the conclusion that on the light soils of the Concord asparagus district nitrate of soda at the rate of 450 pounds per acre will usually give a more profitable increase in the crop when used in connection with materials supplying abundant potash and phosphoric acid in available forms than any larger quantity.

2. What amount of nitrate of soda, if any, can profitably be used in connection with a moderate application of manure?

There are three sets of plots on which nitrate of soda at the rates respectively of 300, 450 and 600 pounds per acre is used in connection with manure at the rate of 20,000 pounds per acre. In these trials nitrate of soda at the rate of 450 pounds per acre has given the best yield in so many instances that it is believed to be the maximum which can usually be profitably used, although in a number of instances the yield on plots to which nitrate had been applied at the rate of 600 pounds per acre has been somewhat greater.

3. At what season does it appear to be best to apply nitrate of soda when used in connection with fertilizers supplying phosphoric acid and potash?

The methods of application under comparison are as follows: —

First. — All the nitrate is applied early in the spring when the bed is first harrowed.

Second. — On other plots all of it is applied at the close of the cutting season and cultivated in.

Third. — On the other set of plots one-half of the nitrate is applied early in the spring and one-half at the close of the cutting season.

The results do not indicate any clearly defined superiority for either method of application, and in the case of the use of nitrate with manure, where also the three methods of application above mentioned were compared, the conclusion is the same.

An effort has been made to determine whether application of the whole or a part of the nitrate early in the spring increases the proportion of the crop during the early part of the season. This does not seem to have been the case where the nitrate is used either with phosphate and potash or with the manure.

4. Another question on which we have sought to throw light is: in what amount, if any, does acid phosphate when used in connection with a liberal application of nitrate of soda and muriate of potash prove useful?

In the effort to answer this question acid phosphate has been employed at three different rates per acre: viz., 300, 450 and 600 pounds. The increases produced by acid phosphate are, at best, relatively small, and the greatest increase has been obtained where it has been used at the rate of 450 pounds per acre, which would seem, therefore, to be the maximum rate which it would pay to use on this soil.

5. Still another question which we have sought to answer has been: in what quantity, if any, can muriate of potash be used with profit in connection with liberal applications of nitrate of soda and acid phosphate?

In these experiments the muriate has been used in three quantities, respectively, at the following rates per acre: 175, 262 and 350 pounds. Even with the smallest of these amounts the increase produced has been large. The highest increase has usually been obtained where the muriate of potash has been used at the rate of 262 pounds per acre, which, therefore, would seem to be sufficient on this soil to meet the maximum requirements of the crop.

6. We have sought to determine which among the various materials which may be used as a source of potash seems best suited to the crop. The materials under comparison have been muriate of potash, wood ashes, high-grade sulfate of potash, low-grade sulfate of potash and kainit. These have all been used at such rates as to furnish an equal amount of actual potash per plot. The muriate of potash has given the highest yields, followed closely by kainit. As the results in different years have been in close agreement I think we are justified in the conclusion that there is no form of potash superior to muriate for the asparagus crop.

7. In connection with the various trials to which I have referred we have also tested the results of the application of a so-called "complete" fertilizer made up of nitrate of soda, acid phosphate and muriate of potash, in connection with manure at the rate of 20,000 pounds per acre. This so-called "complete" fertilizer in connection with manure has not increased the crop in any greater degree than has nitrate of soda when used alone; and while during the past year the combination in which nitrate was used at the rate of 600 pounds per acre has given a slightly larger crop than the combination in which it was used at the rate of 450 pounds, in each of the preceding three years the maximum was obtained with the smaller amount. I believe, therefore, we are justified in the conclusion that neither the acid

phosphate nor the muriate of potash in connection with the manure has been distinctly beneficial, and that in this combination, as when used alone in connection with manure, nitrate at the rate of about 450 pounds per acre appears to be as large an amount as it is profitable to use on the Concord soil.

8. *General Conclusion.* — Without exception, the combination of chemicals used in these experiments has given as large annual yields as the combination of manure at the rate of 20,000 pounds per acre and chemicals, a result which seems somewhat surprising. The largest yield obtained on any plot during the last few years has been on the one annually top-dressed in early spring with chemicals at the following rates per acre: —

Nitrate of soda,	450
Acid phosphate,	450
Muriate of potash,	262

So far as this series of experiments goes, therefore, and it should be remembered that it has continued nine years, we are apparently justified in concluding that this application of chemicals fairly satisfies the requirements of the crop. It is undoubtedly important in this connection to recall the fact that the land on which these experiments are located had not been cultivated for a considerable number of years previous to its selection for this work. In preparation for these experiments, the land was cleared of brush and trees and plowed in the spring of 1906. It then received an application of fertilizers at the following rates per acre: —

Lime,	1 ton.
Fine ground bone,	½ ton.
Acid phosphate,	600 pounds.
Muriate of potash,	350 pounds.
Nitrate of soda,	150 pounds.

The lime was applied by itself, the other materials were mixed, evenly spread and harrowed in. The field was thoroughly prepared in the spring of 1906 and sown to buckwheat. The buckwheat made a heavy growth and was plowed under when fully grown. The field was then harrowed and sown to winter rye. This was plowed under in the early spring of 1907, when the asparagus was set.

It seems quite possible that the thorough preparation which the land received and the fact that so large an amount of vegetable matter was incorporated with the soil before the plants were set account for the exceptionally favorable comparative results from the application of commercial fertilizers alone.

9. *Relation of the Fertilizer Treatment to Rust.* — The fact that there has been but little rust in the Concord asparagus district during the past three years has undoubtedly considerably reduced our chances for determining whether there has been any direct effect upon the extent to which rust has affected the crop which can be attributed to variation in fertilizer treatment. The results of our study of this question, however, which, as will be understood, must be a matter of judgment based upon careful inspection, convince us that the location of the different plots in relation to direction of prevailing winds which might carry rust spores from centers of infection outside the experimental field has had much more to do with the extent to which rust has affected plants in the different plots than variation in fertilizer treatment. Most careful observations, however, by two different observers working independently have led to conclusions as to the relative amount of rust in different plots which are in substantial agreement. These conclusions may be thus stated: the application of nitrate of soda at the close of the cutting season promotes a vigorous growth and seems to increase the capacity of the foliage to resist rust; at least, two observers have agreed that there is less rust on plots to which nitrate of soda is applied at the time indicated. This is true whether the nitrate is applied one-half in the early spring and the balance at the close of the cutting season, or all at the close of the cutting season.

While, therefore, for the reasons first pointed out, it has been a matter of great difficulty to determine whether there has been a connection between the amount of rust and the fertilizer treatment, I am strongly inclined to believe that the application of a moderate amount of nitrate of soda, perhaps 150 to 200 pounds per acre, at the close of the cutting season is likely to reduce the amount of injury from this disease.

THE CRANBERRY SUBSTATION, WAREHAM.

The general lines of work in the cranberry substation during the past year have been similar to those previously in progress. Experiments with different fertilizer materials and different fertilizer combinations, the study of the life histories and habits of insects and their relations to the crop, and methods of destroying those that are injurious, experiments in co-operation with the United States Department of Agriculture in methods of treatment for the prevention of disease, methods of frost protection, weather observations and frost warnings, a study of methods of preparing the crop for market, and storage experiments have been the main lines of work. Particular emphasis has been placed this year on a study of the conditions and methods of handling and storage as affecting keeping quality. Results which seem likely to prove of great value have been obtained, but it has been impossible to complete this work in season for the inclusion of the usual bulletin giving the results of the cranberry investigations in this report. The bulletin covering the operations of the year 1915 will be included in the report published in January, 1917. The bulletin as a separate, however, will be distributed as soon as it can be published.

The cranberry crop on the station bog in 1915 was seriously reduced by the ravages of the tip worm. The fruit, however, was of good quality, the fruit worm did relatively little injury, and the prices realized for the fruit were quite satisfactory. The following tables show in detail both expenditures and returns. The salary of Dr. Franklin is not included in the tables of expenditures. These are divided in such a manner as to show ordinary expenditures which would be involved in the management of a cranberry bog on a commercial basis, and the expenditures for the experimental work.

Bog Account.

Maintenance: —		
Tools and similar equipment bought or repaired,	$62 99	
Oil for engines, etc.,	82 40	
Pumping plant maintenance and repairs,	146 26	
Pumping labor,	28 85	
Mowing of upland,	42 80	
Weeding,	21 61	
Cleaning out ditches,	4 17	
Lumber and hardware,	43 01	
Raking vines after picking,	73 95	
Resanding bog,	71 82	
Sundries,	17 31	
Miscellaneous labor,	42 52	
		$936 34
Harvesting: —		
Picking,	$591 62	
Separating,	54 28	
Screening,	189 42	
Packing,	27 40	
Carting,	35 95	
Coopering and mending boxes,	13 30	
Packing materials,	172 20	
		1,084 17
Improvements: —		
Building roads,		59 43
Total,		$2,079 94

Experimental Account.

Labor,		$450 48
Supplies and apparatus,		52 82
Chemicals (including fertilizers and insecticides),		25 30
Stationery and postage,		3 25
Traveling expenses,		67 15
Carpentering and painting,		18 00
Stenographer,		11 11
Blueberry experiment: —		
Tools,	$11 45	
Surveying,	7 50	
Turfing and grading,	232 19	
		251 14

Contingent: —		
Freight,	$1 65	
Surveying,	2 50	
Express,	5 84	
Telephone,	30 65	
Furnishings,	13 25	
Fuel,	4 00	
Incidentals,	25	
		$58 14
Total,		$937 39

The total sales for the year were as follows: —

Fruit: —		
Crop of 1914,	$764 67	
Crop of 1915,	1,521 82	
		$2,286 49
Miscellaneous,		8 85
Total,		$2,295 34

Of the crop of 1915, we still have on hand a considerable proportion retained for use in storage experiments, — 75 barrels, estimated to bring in $420, while the balance still due on sales of the 1915 crop is $495. The total proceeds from the sale of the 1915 crop, therefore, must amount to substantially $2,436.

The following comparative statements of receipts and expenditures will be of interest: —

YEAR.	Annual Receipts, Berries and Vines.	Annual Commercial Expenditure.	Annual Experimental Expenditure.
1911,	$5,484 43	$1,998 81	$1,639 94
1912,	1,079 87	1,985 71	1,243 25
1913,	6,675 60	2,238 02	897 51
1914,	1,973 29	1,902 07	984 69
1915,	2,445 67	2,079 94	937 39
Total,	$17,658 86	$10,204 56	$5,702 78
Average, five years,	$3,531 77+	$2,040 91+	$1,140 55+

THE AGGLUTINATION TEST FOR THE ELIMINATION OF WHITE DIARRHEA IN POULTRY.

The work of Jones of Cornell, Rettger of Yale, and Dr. Gage of this station — the latter fully reported in Bulletin 163 — having shown that white diarrhea, which has been the occasion of so much loss to poultry keepers because of the death of so large a proportion of young chicks affected with the disease, is in most cases due to the infection of the egg from the ovary of the hen producing it, and that the hens harboring the organism can be almost certainly detected by a comparatively simple blood test, it was decided to carry out this test on the flocks of poultrymen applying for it in so far as the facilities and force at our disposal made it possible on the basis of a payment to the station at the rate of five cents for each fowl tested. This work was begun in a small way in the winter of 1915. It became possible in the late summer to undertake it upon a considerably more extensive scale through an arrangement for the collection of the samples of blood by Prof. A. G. Lunn, who is engaged in poultry extension work. It was thought that Mr. Lunn would be able to collect samples in as great number as could be handled in our laboratories with the force available for the work without serious interference with his extension duties. This expectation was not fully realized. The number of blood samples which he found it possible to take was not sufficiently great nor forwarded with sufficient regularity to afford steady employment for our laboratory forces. A good beginning, however, was made, and between September 11 (when the work began) and the end of the year 2,728 birds were tested. So far as follow-up work and the reports from individuals whose breeding flocks have been tested indicate, the results of the work are very satisfactory, as the losses of chicks hatched from eggs of birds which passed the test have been far less than the losses in chicks belonging to the same owners when eggs from untested breeding flocks were hatched.

INVESTIGATION.

The department reports which follow present a general description of the principal experimental work in each, and to these reports reference should be made for detailed information.

Department of Agriculture.

The lines of work followed in the agricultural department are mainly concerned with investigations concerning the relations of varied use of fertilizers, manures and various fertilizer materials and lime to the productive capacity of soils with different crops. Our main lines of investigation have been continued during the past year, but are being more and more closely correlated with chemical investigations conducted by Professor Morse and his assistants. The outcome of the work in progress is a constantly increasing knowledge of the conditions affecting productive capacity. One line of investigation which has been followed for some twenty-six or twenty-seven years indicates so decisively and so consistently throughout this long series of years that the use of lime has not increased the availability of the soil potash that we have had no hesitation in advising against dependence upon lime, during this period when potash cannot be purchased, as a means of bringing soil potash within the reach of the crop. The report of the agriculturist calls attention to a few only of the lines of investigation in progress.

The report upon the results of the season on Field A, devoted to a comparison of different materials as sources of nitrogen, is of particular interest as it shows so clearly how important it is to consider the effect of residual material in estimating the relative value of such nitrogen fertilizers as nitrate of soda and sulfate of ammonia. It has been found that even without application of lime, splendid crops of clover can be produced where nitrate of soda as a source of nitrogen has been continuously used for twenty-six years. On the other hand, where sulfate of ammonia has been regularly applied, clover is a practical failure unless lime be applied in large quantities. Another point very strikingly brought out by the results of the year is the possibility of producing splendid crops of clover on a soil physically well adapted to the crop and liberally supplied with materials furnishing phosphoric acid and potash without any application whatever of nitrogen fertilizers during the long period of time that the experiment has continued. On the limed portions of the different plots, the no-nitrogen plots in 1915 gave yields practically identical with those produced on plots where dried blood as a source of nitrogen has been applied in liberal amounts annually. The yield on the limed portion of the no-nitrogen plots was only slightly inferior to the yields obtained where nitrate of soda and sulfate of ammonia have been annually applied, and the plots which have received no applied nitrogen in any form during twenty-six years gave a yield of clover at the rate of 253 pounds per acre greater than that produced where manure has been applied annually. If we include both the limed and unlimed portions of all the plots, the yield on the plots to which no nitrogen has been applied for twenty-six years was last year substantially equal to the yield on any of the plots, and was at the rate of slightly over four tons per acre. These results indicate clearly that the highest economy in the production of clover is not possible when manure is applied to the land; manure should certainly be reserved for other crops.

The report presents extensive averages which show in a striking way the relative adaptation to different crops of the two leading potash salts, muriate and high-grade sulfate. Among crops for which the former is the best, as shown in most cases by results extending over a considerable number of years, are asparagus, currants, sugar beets, ensilage corn, squashes, carrots and onions, while the muriate also has invariably given a heavier yield of corn stover than the sulfate. Among crops for which the sulfate is clearly best adapted, this statement also in most cases depending upon results extending over a considerable number of years, may be mentioned blackberries, raspberries, strawberries, rhubarb, potatoes, cabbages, soy beans, alfalfa and clovers, while the yield of grain of the corn crop has been slightly greater on sulfate than on muriate.

The report on the results of top-dressing permanent mowings brings out in a striking way the possibilities in the direction of hay production on soil naturally adapted to grasses and clovers under this system of management. The average of twenty-three years' experiments has been the production, usually in two crops annually, of nearly three tons of well-made hay to the acre. The average annual cost of the materials used in top-dressing has amounted to from $10 to $12 per acre. The possibilities of profit at prices which hay usually brings are clearly apparent. The substitution of a mixture of basic slag meal (2,070 pounds) and muriate of potash (647½ pounds) for one ton of wood ashes applied in the earlier years of the experiment appears to have been a distinct improvement.

Department of Horticulture.

The work in this department during the past year has not been carried in any special line of investigation to a point making a definite report of results at this time desirable. The investigations in progress include both such as relate to problems of a research character which have been looked after by Dr. Shaw, and more practical experiments, most of which are under the direct charge of Professor Sears. Professor Waugh's report includes an outline statement indicating the nature of the principal lines of investigation.

Department of Poultry Husbandry.

The report of Dr. Goodale of the department of poultry husbandry deals mainly with lines of general investigation connected with the factors which influence egg production. Some of Dr. Goodale's principal conclusions are: —

First, that the prime factor essential for satisfactory winter egg production from strong stock is early maturity. The records of the station flocks show that, even in the case of birds of one breed hatched from eggs from the same pen supposedly made up of birds of similar breeding, there is an astonishing variability in the age at which the first egg is produced, namely from 195 to 300 days.

Second, the prime factor essential for high annual egg production aside from early maturity is nonbroodiness. A considerable flock of Rhode Island Red hens, none of which were broody during their first year, has been selected and will be used for breeding in the effort to produce a nonbroody strain. Dr. Goodale concludes that if broodiness can be eliminated, the increase in annual egg production may very likely amount to as much as 33⅓ per cent.

Another point brought out by the work of the year is that chicks reared on new land thrive very much better than those raised on land over which chicks have previously ranged, even if for only a short period of time, and this appears to be true even when the land is not infected with any disease organism.

Department of Chemistry.

Besides the usual control bulletins on fertilizers and feeds there have been three bulletins published from this department during the past year: No. 164, "Substitutes for Milk in the Rearing of Dairy Calves and the Cost of Rearing the Dairy Cow;" No. 165, "Effects of Sulfate of Ammonia on Soil;" and No. 166, "Improved Methods for Fat Analysis."

The results presented in Bulletin 164 show that there are a number of fairly satisfactory calf feeds which can be used very largely in place of milk in the rearing of dairy calves. The bulletin also describes a home-made combination which seems to serve the purpose equally well. The results bearing upon the cost of rearing a dairy cow indicate that this usually is likely to amount to about $75 to $85 up to the age of two years.

Bulletin 165 presents results which lead to the conclusion that one of the permanent effects of continuous use of sulfate of ammonia as a fertilizer is that the sulfuric acid enters into combination with calcium in the soil and that as a result there is a considerable loss of lime. The results indicate further that after the lime is to a considerable extent exhausted, there is likely to be a formation of salts of iron and aluminium, and culture studies with seedling plants in solutions to which small quantities of iron or aluminium sulfate were added demonstrated a highly injurious action of these salts on the roots, especially of clover seedlings. These studies throw important light upon the causes of the almost absolute failure of clover on plots in one of our important series of experiments in which sulfate of ammonia has been used continuously for a considerable number of years.

Bulletin 166, on fat analysis, is of a highly technical character, but presents the results of long-continued and extremely careful investigation, which has resulted in the development of a number of methods either entirely new or greatly improved as compared with methods previously known.

The report of the head of the department of chemistry presents a very complete outline of the various lines of investigation and general work conducted in this department of the experiment station.

DEPARTMENT OF BOTANY.

The work of this department has followed about the usual lines but has been considerably strengthened in the direction of greater attention to and closer study of a number of plant diseases. Two diseases which seem to be rather serious which are new in the State have been brought to attention during the year, — mosaic disease of the sweet pea and ringspot of cauliflower. These are being investigated.

Fungous diseases of most kinds were more general and more serious during the summer of 1915 than usual, undoubtedly because of the unusual moisture conditions of July and August. Among such diseases, the late blight of the potato probably caused greater damage than any other. The downy mildew of the cucumber appeared earlier and was much more severe than usual, affecting both hothouse and out-door crops, many of the latter being practically complete failures on account of it.

Some phases of the work of the department during the year seem to indicate that powdery scab, which it was at one time feared would become a serious disease of the potato in this State, apparently finds climatic conditions unfavorable to development, and it is thought this disease will give us little or no trouble.

White pine blister rust, one of the most serious diseases that has ever affected that species, has been found in a number of widely scattered centers, and is particularly abundant in the western part of the State. Some phases of the life history of the fungus causing this disease are being carefully studied.

DEPARTMENT OF ENTOMOLOGY.

The work in this department has followed about the usual lines, but especial attention has been directed to the study of such insects as reports and correspondence indicated were proving injurious to an exceptional degree in all cases in which the life histories of these insects and satisfactory means of preventing injury were not already known. Correspondence indicated an exceptional degree of injury from the work of plant lice and scale insects. Fairly satisfactory remedies for these are already known.

The fact was brought to the attention of the department that the red spider was doing an immense amount of damage to hothouse cucumbers, and as no satisfactory methods of prevention were known, a graduate assistant has begun a special investigation.

During the summer the fact was brought to our attention that the larvæ of an insect which proved to be the strawberry crown girdler was doing very great injury to young white pines in the forest tree nurseries of the State. The value of the stock destroyed in one of these nurseries was estimated to be no less than $15,000. The insect attacked not only the white pine but other conifers, which were completely girdled at a distance of from one to three inches below the surface of the ground, and occasionally attacked even sugar maples as well. Methods of treatment which it is believed will be quite effective in protecting from a similar attack next year were suggested and put into operation.

The head of the department calls attention to the vital need of additional assistance in order that more satisfactory service to the agricultural interests of the State may be rendered.

DEPARTMENT OF VETERINARY SCIENCE.

The general lines of investigation in this department have been similar to those to which attention has recently been devoted. Principal emphasis has been laid upon a continued investigation of bacillary white diarrhea and methods of its elimination from the flocks of the State, and the use of serum for the prevention of hog cholera. One new line of investigation has been undertaken. This is of a highly technical research character, the object in view being to determine the causes and if possible the methods of prevention of some of the more serious bee diseases. European foul brood is the one at present receiving most attention.

One bulletin has been issued by the department during the year, namely, Bulletin 163, "Bacillary White Diarrhea in Young Chicks in Massachusetts." Investigation has shown that white diarrhea is found in practically all parts of the State. The proportionate losses in different districts vary considerably, but in the aggregate the losses from this disease are very serious. The disease is carried by means of eggs from unsound stock, through the purchase of day-old chicks or of infected mature stock. The bulletin urges that poultry keepers co-operate with the station in the effort to free our flocks from this infection.

Department of Agricultural Economics.

Two main lines of investigation have engaged attention in this department: namely, agricultural insurance and the production, storage and distribution of onions.

The study of agricultural insurance has consisted mainly in inquiries to determine the extent to which such insurance is offered, the cost of such insurance and the general conditions and results. There appear to be only two types of agricultural insurance practiced in New England, namely, live stock insurance and insurance of the tobacco crop against damage by hail. Live stock insurance is confined to the insurance of race horse stock and exhibition stock when shipped to shows. The premium rate is about 10 per cent., which is excessively high, and it is not surprising that inquiry discloses the fact that such insurance is not at all general. The rate of insurance of tobacco against damage by hail is about 5 per cent. Such insurance is by no means general, but is considerably practiced, with results which seem in general to be satisfactory.

The investigations in connection with the production, storage and distribution of onions indicate that the cost of production and marketing appears to be about 36 to 40 cents per bushel. The average acre yield in 1914 was about 480 bushels. Of the total crop produced about 40 per cent. is usually stored. The average cost of storage, inclusive of shrinkage, is about 14.6 cents per bushel. The March price during the years covered by the investigation (1914 and 1915) has averaged about 51 per cent. higher than the September price and 61 per cent. higher than the October price, these advances affording a good margin of profit on storage.

DEPARTMENT OF MICROBIOLOGY.

Since this department has thus far worked without adequate laboratory accommodations and equipment, the work along such lines of investigation as have been undertaken has been mainly of a preliminary character.

The department has published one bulletin of a highly technical character, No. 167, which presents the results of a careful study of the relation of hydrogen ion concentration to the proteolytic activity of a few species of bacteria. It is believed that this work will prove of value as a basis for investigations having very direct, close and important relation both to the productive capacity of soils and the sanitary qualities of milk.

DEPARTMENT OF METEOROLOGY.

The usual weather observations have continued. Weather signals received from the United States Weather Bureau have been displayed. The usual monthly bulletins have been regularly published.

REPORTS AND BULLETINS.

The reports of the treasurer and of the different departments immediately follow the director's report. The bulletins to which reference has been made will be found in Part II. of the annual report.

WM. P. BROOKS,
Director.

REPORT OF THE TREASURER.

ANNUAL REPORT

Of Fred C. Kenney, Treasurer of the Massachusetts Agricultural Experiment Station of the Massachusetts Agricultural College, for the Year ending June 30, 1915.

United States Appropriations, 1914–15.

	Hatch Fund.	Adams Fund.
Dr.		
To receipts from the Treasurer of the United States, as per appropriations for fiscal year ended June 30, 1915, under acts of Congress approved March 2, 1887 (Hatch fund), and March 16, 1906 (Adams fund),	$15,000 00	$15,000 00
Cr.		
By salaries,	$12,678 44	$14,586 63
labor,	1,124 44	289 17
publications,	11 50	–
heat, light, water and power,	26 79	–
chemicals and laboratory supplies,	223 78	69 46
seeds, plants and sundry supplies,	375 21	29 48
fertilizers,	449 70	–
library,	19 43	6 09
tools, machinery and appliances,	32 91	–
scientific apparatus and specimens,	–	10 81
live stock,	41 00	–
traveling expenses,	16 80	8 36
Total,	$15,000 00	$15,000 00

State Appropriation, 1914–15.

Cash balance brought forward from last fiscal year,	$13,797 08
Cash received from State Treasurer,	31,000 00
fertilizer fees,	9,892 00
farm products,	2,377 00
miscellaneous sources,	13,079 15
	$70,145 23

Cash paid for salaries,	$20,413 61
labor,	15,669 91
publications,	1,951 78
postage and stationery,	1,518 25
freight and express,	463 53
heat, light, water and power,	452 64
chemicals and laboratory supplies,	1,562 58
seeds, plants and sundry supplies,	1,737 43
fertilizers,	385 86
feeding stuffs,	1,360 78
library,	621 37
tools, machinery and appliances,	787 30
furniture and fixtures,	709 20
scientific apparatus and specimens,	1,111 90
live stock,	145 05
traveling expenses,	2,182 06
contingent expenses,	119 55
buildings and land,	1,640 44
miscellaneous,	283 80
balance,	17,028 19
Total,	$70,145 23

DEPARTMENT OF AGRICULTURE.

E. F. GASKILL.

In reporting the work of the agricultural department for the past year the plan generally adopted by the department for presenting the experimental data has been followed. As stated in earlier reports the experimental work of this department has dealt largely with various phases of the question of soil fertility. It was early recognized that results obtained in such work for one, two or three years would be of little value because of the favorable or unfavorable effect of a wet or a dry season on crop production; therefore, many of the experiments have continued over a long period of years. It has not been the custom to report the work in detail each year, but to mention only a few of the more important results for the year. Each report may, therefore, be considered a report of progress, and a complete file of the annual reports will present a fairly complete record of the different experiments.

The work this year has involved the use of 200 field plots, 13 orchard plots, 23 pasture plots, 143 closed plots and 389 pots.

Field A, or the Nitrogen Experiment.

This is the twenty-sixth year of the experiment which has for its object a study of the relative value as sources of nitrogen of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. There are 8 plots which receive nitrogen from the following sources, and 3 check plots which receive no nitrogen. Barnyard manure is used on 1 plot, nitrate of soda on 2 plots, sulfate of ammonia on 3 plots, and dried blood on 2 plots. All plots receive the same amounts of actual phosphoric acid and actual potash.

One-half of each plot received in 1913 an application of hydrated lime at the rate of 2 tons per acre.

The crop this year was clover. Two splendid crops were harvested, and a very fair third crop was turned under in November. The average yield for this year on the different nitrogen and no-nitrogen plots is shown in the following table: —

Average Yields per Acre, 1915 (Grass and Clover).

Plots.	Limed (Pounds).	Unlimed (Pounds).	Average (Pounds).
Nitrate of soda, 1 and 2,	8,450	7,800	8,125
Dried blood, 3 and 10,	8,050	8,600	8,325
Sulfate of ammonia, 5, 6 and 8,	8,867	7,300[1]	8,083
No nitrogen, 4, 7 and 9,	8,053	8,133	8,093
Manure, 0,	7,800	8,300	8,050

[1] Grasses in much larger proportion than on other plots.

As the crop stood in the field there was a marked difference between the limed and unlimed portions of all plots except the nitrate of soda plots and the manure plot. It was desired to obtain photographs of the crop on the limed and unlimed areas of the different plots, and owing to the unsettled weather conditions it was necessary to make the stacks over three or four times, which caused a loss of leaves and consequently reduced the weights somewhat. This loss was most serious on the plots with the heavier yields of clover.

The following table shows the yield per acre obtained this year on the different plots: —

Yields per Acre (Pounds).

Plot.	Fertilizer.	First Crop.		Second Crop.	
		Limed.	Unlimed.	Limed.	Unlimed.
0	Stable manure,	4,100	4,300	3,700	4,000
1	Nitrate of soda, Muriate of potash, Dissolved boneblack,	5,800	3,500	3,800	3,900
2	Nitrate of soda, Sulfate of potash-magnesia, Dissolved boneblack,	4,100	4,700	3,200	3,500
3	Dried blood, Muriate of potash, Dissolved boneblack,	4,400	4,800	3,500	3,900

Yields per Acre (Pounds) — Concluded.

Plot.	Fertilizer.	First Crop.		Second Crop.	
		Limed.	Unlimed.	Limed.	Unlimed.
4	Sulfate of potash-magnesia, Dissolved boneblack,	4,600	4,600	3,600	4,100
5	Sulfate of ammonia, Sulfate of potash-magnesia, Dissolved boneblack,	5,000	3,900	3,900	2,600
6	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	5,300	4,400	3,900	3,100
7	Muriate of potash, Dissolved boneblack,	4,460	3,600	3,600	4,000
8	Sulfate of ammonia, Muriate of potash, Dissolved boneblack,	5,000	4,600	3,500	3,300
9	Muriate of potash, Dissolved boneblack,	4,300	3,800	3,600	2,300
10	Dried blood, Sulfate of potash-magnesia, Dissolved boneblack,	4,600	4,800	3,600	3,700

On the basis of 100 for nitrate of soda, the relative standing of the different nitrogen plots and no-nitrogen plots, as measured by total yield during the past season, was as follows: —

	Grass and Clover (Per Cent.).
Nitrate of soda,	100.00
Dried blood,	102.46
No nitrogen,	99.61
Sulfate of ammonia,	99.48
Manure,	99.10

The relative standing of the different materials as indicated by total yield for the twenty-six years during which the experiment has continued is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Manure,	93.74
Dried blood,	93.57
Sulfate of ammonia,	88.81
No nitrogen,	73.40

On the basis of increase as compared with the no-nitrogen plots the relative standing for the different fertilizers for the twenty-six years is as follows: —

	Per Cent.
Nitrate of soda,	100.00
Manure,	76.47
Dried blood,	75.83
Sulfate of ammonia,	57.93

Considering the relative standing of the different nitrogen fertilizers on the basis of yields per acre, it will be seen that with a mixed crop of clover and grass there is very little difference between the different materials, and that the no-nitrogen plots gave yields about as large as those receiving nitrogen.

COMPARISON OF MURIATE AND HIGH-GRADE SULFATE OF POTASH (FIELD B).

The crops grown on this field the past year were asparagus, blackberries, raspberries, currants, rhubarb, potatoes, mangels and alfalfa. The results obtained are in agreement with those in previous years, with one exception, — the yield of asparagus this year was slightly better on the sulfate plot than on the muriate plot. This is the twelfth year this crop has been grown on these plots, and the only time that the yield has not been decidedly in favor of the muriate. We have pointed out in previous reports the fact that muriate has given better results in dry seasons, but we are not ready to say the difference in yield this year is due to the abnormally wet season.

Considering the different crops grown during the twenty-three years of the experiment, the muriate has proved the better source of potash for the following: asparagus (eleven years), currants (four years), mangels (two years), sugar beets (one year), corn, ensilage (one year), corn stover (seven years), sweet corn stover (one year), squashes (three years), carrots (two years), onions (two years), celery (one year), oat hay (one year), and vetch and oats (two years).

The sulfate has proved the better source of potash for the following crops: asparagus (one year), blackberries (ten years), raspberries (ten years), strawberries (eleven years), rhubarb (twelve years), potatoes (twelve years), corn, grain (seven years), sweet corn, ears (one year), cabbages (ten years), soy beans (four years), alfalfa (four years), crimson clover (one year), common red and alsike clover (one year), and mammoth red clover (one year).

NORTH CORN ACRE.

For twenty-six years there have been under comparison on this field two fertilizer mixtures. In one, the percentage of potash is high and that of phosphoric acid low; in the other (which represents about the average analysis of the commercial corn fertilizers offered on our markets), the percentage of phosphoric acid is high and that of potash low. For twenty years the rotation on this field has been two years grass and two years corn. The seed (a mixture of timothy, red top and clover) has usually been sown in the standing corn the latter part of July. The soil has not had the benefit of a green manure crop nor an application of manure during the twenty-six years of the experiment. The turf and corn stubble which have been plowed under have been the only source of humus. The crop this year was corn. The yield was somewhat smaller than in previous years, but it is believed that the abnormally wet season was more responsible for the lower yield than the lack of fertility. Judged on the basis of crop production, it would seem that the fertility of the soil had been maintained by the use of commercial fertilizer alone.

The yield of crib-dried corn obtained this year was at the rate of 46 bushels per acre on the combination rich in phosphoric acid, and the stover on this plot was at the rate of 5,420 pounds per acre. On the plot receiving the combination richer in potash, the yields were at the following rate: crib-dried corn, 35.1 bushels; stover, 5,060 pounds.

NORTH SOIL TEST.

This experiment began in 1890 and has for its object a study of the effect of the continued use of fertilizers containing single plant-food elements and different combinations of plant-food elements for different crops; also the effect of lime added to each fertilizer under comparison.

This year the crop was mixed grass and clover. The following table gives the fertilizer schedule and the yields per acre obtained this year on the different plots: —

Yields per Acre (Pounds).

Plot.	Fertilizer.	Limed.			Unlimed.
		Hay.	Rowen.	Total.	Hay.
1	No fertilizer, ...	1,260	220	1,480	920
2	Nitrate of soda, ...	1,400	180	1,580	1,440
3	Dissolved boneblack, ...	1,200	180	1,380	1,180
4	No fertilizer, ...	1,400	820	2,220	1,020
5	Muriate of potash, ...	3,700	3,050	6,750	1,580
6	Nitrate of soda, ... Dissolved boneblack, ...	3,500	690	4,190	1,280
7	Nitrate of soda, ... Muriate of potash, ...	3,800	1,760	5,560	960
8	No fertilizer, ...	1,600	720	2,320	520
9	Dissolved boneblack, ...	3,600	1,620	5,220	580
10	Nitrate of soda, ... Dissolved boneblack, ... Muriate of potash, ...	4,200	1,600	5,800	900
11	Plaster, ...	1,100	280	1,380	460
12	No fertilizer, ...	2,300	640	2,940	480
13	Nitrate of soda, ... Dried blood, ... Dissolved boneblack, ... Muriate of potash, ...	8,900	2,220	11,120	1,340

The materials are not used in such quantities as would be expected to produce large crops. The data accumulated during the twenty-six years of the experiment have helped materially to determine the specific plant-food requirements of different crops.

Grass Plots.

In this experiment different materials are used in rotation as top-dressing for grassland. The experiment began in 1893; in 1901 and 1902 some portions of the plots were plowed and reseeded; since then the field has been continuously in grass. The following table gives the fertilizer schedule and the yields per acre for the past season: —

FERTILIZERS.	Hay (Pounds).	Rowen (Pounds).	Total (Pounds).
Barnyard manure,	3,519	2,172	5,691
Bone and potash,	3,231	2,320	5,551
Slag and potash (earlier ashes plot),	4,399	2,704	7,103

The average yields to date under the three systems of top-dressing are: —

	Pounds per Acre.
When top-dressed with manure,	6,007
When top-dressed with bone and potash,	5,898
When top-dressed with wood ashes,[1]	5,610

The clover, which had largely disappeared during the recent dry seasons, was quite abundant this year, especially in the second crop.

SULFATE OF AMMONIA *v.* NITRATE OF SODA AS A TOP-DRESSING FOR PERMANENT MOWINGS.

The experiment to compare sulfate of ammonia and nitrate of soda when used as a top-dressing for permanent mowings has been continued. There are five plots, all of which receive the following mixture: bone meal, muriate of potash, slag.

In addition, two plots receive sulfate of ammonia and two plots receive nitrate of soda, the two being used in such quantity as to supply equal nitrogen. This is the eighth year of the experiment. The results obtained are in favor of the nitrate of soda for the first crop, with very little difference between the two for the second crop, and the check plot or no-nitrogen plot producing more rowen than either the nitrate of soda or sulfate of ammonia plots. The heavier rowen crop on the no-nitrogen plot is due to the fact that the growth on this plot is mostly clover. These results are in accord with those obtained in previous years and indicate in a striking way that beneficial results are obtained by top-dressing with sulfate of ammonia and nitrate of soda, and that the results are immediate but not lasting.

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[1] Slag and potash now used.

LIME EXPERIMENT.

An experiment to study the relative value of different sources of lime on the basis of equal applications of combined calcium and magnesium oxides was begun in 1914. The field selected for this experiment is the one on which for so many years we studied the effects of spring and winter applications of manure. The plots have received no manure or fertilizer since 1911.

The crop this year was medium green soy beans grown for seed. The crop was harvested October 18 and 19, and threshed in November. The following table gives the yields per acre on the different plots: —

Plot.	LIME.	Beans (Bushels).	Straw (Pounds).
1	Hydrated lime,	31.20	2,484
2	Marl,	30.00	2,435
3	Ground limestone,	30.02	2,359
4	No lime,	28.86	2,273
5	Limoid,	35.25	3,209

VARIETY TEST POTATOES.

This year we have had 21 different varieties of potatoes in our variety test work. The varieties planted this year were selected from the more promising varieties grown last year. This seed originally came from widely different sources; the present season is the fourth that these varieties have been grown on our plots. The plan included two rows of each variety with every seventh row as a check. The Green Mountain variety was planted in the check rows.

The following table shows the variety and yield obtained this year. Those with one star ranked among the five best yielders in one of the preceding years; with two stars, ranked among the five best yielders two of the preceding years; and with three stars, ranked among the five best yielders all three of the preceding years.

Early.		Late.	
Variety.	Bushels per Acre.	Variety.	Bushels per Acre.
Buckbee's Extra Early Rockford (?),	198.2	Clyde, ...	250.6
Early Six Weeks, ...	153.0	Diamond, ...	286.3
Early Surprise,***	314.8	Early White Albino, . . .	342.7
Irish Cobbler,**	287.9	Farmer,**	374.5
Johnson's Flour Ball,*	293.4	Gray's Mortgage Lifter, . .	307.6
Petoskey,*	279.5	Green Mountain, ...	331.5
Trust Buster,***	289.7	Northern Star,*	367.8
		Quick Crop,***	371.3
		Sir Walter Raleigh,***	358.6
		Snow, ...	275.8
		Sutton's Early Monarch,** . .	361.7

In this work the seed has always been treated for the prevention of scab, the crop has received liberal fertilizer and careful attention, particularly to spraying and cultivation. The seed has been carefully selected and stored each year. By growing the different varieties for four years, and each year discarding the poorer ones, we have several very good varieties left.

It is hoped another year to begin an attempt to improve some of the varieties by the tuber unit and hill selection method, and to determine, if possible, how long certain varieties when selected in this way may be grown in this locality before "running out."

DEPARTMENT OF HORTICULTURE.

F. A. WAUGH.

The work of the experiment station in horticultural lines has continued during the year in accordance with policies already well established. The research work, in charge of Dr. Shaw, has emphasized increasingly the problems of pomology, and has given somewhat less attention to problems of plant breeding. The practical experiments in pomology conducted by Professor Sears have been devoted chiefly to methods of orchard practice. During the year there has been much emphasized the increased demand for experimental work in market-gardening lines. Definite plans for work in this field are being matured, especially under the direction of Prof. H. F. Tompson. Considerable demand exists also for experimental work in floriculture.

The following outline gives a brief résumé of the work of the year: —

1. Plant breeding work is still continued though in diminishing measure. The principal problems recently touched are as follows: —

(*a*) Correlation between seed weight and vine length in peas.

(*b*) Selection within pure lines in peas.

(*c*) Pigmentation in garden beans. A considerable amount of material ready for publication.

(*d*) Selection of summer squashes in the attempt to isolate pure lines. Interesting practical results have been secured, but nothing of sufficient scientific importance for publication.

2. Co-operative observations of summer temperatures, especially in orchard lands, have been undertaken in Franklin County under direction of Dr. Shaw.

3. Experiments in apple storage, with special reference to the effects on quality, have been conducted by Dr. Shaw with the

co-operation and advice of other members of the department of pomology.

4. Some experiments in the formation of heads on young apple trees, using different methods of pruning, are now under way by Mr. Armstrong under direction of Dr. Shaw.

5. Perhaps the most important experiment under way in this division is the one conducted by Dr. Shaw in the correlation existing between stock and scion in grafted fruit trees. This project is an extensive one and is undertaken to cover a considerable term of years. It is now getting under way.

6. Dr. Shaw has also been making extended studies of tree and leaf characters in different varieties of apples. Much interesting material has been collected.

7. Extended practical experiments in orcharding management are being conducted by Professor Sears. The principal problems in hand are as follows: —

(*a*) Experiments in spraying, with special reference to use of oil on apple trees.

(*b*) Comparative test of cover crops.

(*c*) Top grafting experiments, designed to test the influence of stock upon scion in top-worked apple trees. This experiment is naturally closely correlated with the stock and scion experiments planned on a larger scale by Dr. Shaw.

(*d*) Extended observations of varieties of fruits.

(*e*) A comparison of southern-grown nursery stock with northern-grown.

(*f*) A comparison of one-year trees against two-year nursery trees in orchard planting.

(*g*) Experiments in the pruning of nursery trees at planting time.

(*h*) Summer pruning experiments, which thus far have given chiefly negative results.

DEPARTMENT OF POULTRY HUSBANDRY.

H. D. GOODALE.

The Status of Work in Breeding for Increased Egg Production.

The work was begun late in the fall of 1912, with showroom stock where no attention had ever been paid to egg production. Little was known about birds placed in the laying houses except that they were hatched some time in the preceding spring, but whether early or late in the season was not recorded. These birds were trapnested during that winter and the following spring were mated to males of similar but otherwise unknown ancestry. These matings, therefore, to all intents and purposes were entirely at random so far as egg production was concerned. Only about half the pullets reared were suitable for placing in the laying houses. This generation furnished us our first adequate data. These birds and many of their parents were mated for the pullets that were placed in the laying houses in the fall of 1914. The results, however, were disappointing, due probably to some secondary factor or group of factors. The egg production of the pullets of the same matings was entirely unlike in the two winters. The pullets now in the laying houses will furnish us data for the fourth generation. At this writing a very satisfactory egg production is being secured.

A study of the data at hand indicates the following tentative conclusions: —

First. — We have been unable to interpret the egg records of the strain of Rhode Island Reds kept at this station in the same way that the records of the Maine station have been interpreted.

Second. — The prime factor in securing winter egg production from strong stock is early maturity.

Third. — The prime factor in securing a high annual egg production, besides early maturity, is nonbroodiness. The addition of early maturity and nonbroodiness to the station strain should result in a big increase in egg production.

Work along our main lines has proceeded as usual. The accumulation and handling of the necessary data require a large amount of tedious routine work. In all probability it will be necessary to continue this work for several years, although it is hoped that certain phases can be brought to a close sooner.

A considerable number of nonbroody Rhode Island Red hens is now on hand. There is also a large number of pullets bred for nonbroodiness in the laying houses. A study of the data on broodiness shows that whenever a hen goes broody her egg production falls off about 40 per cent. As each hen, on an average, goes broody about five times in her pullet year, it means that if broodiness can be eliminated an increase in annual egg production of about $33\frac{1}{3}$ per cent. can be secured. On a flock average of 120 eggs per annum it means 40 eggs, or from 80 to 100 cents, since these additional eggs are produced during the summer and fall.

The number of nonbroody hens on hand enables us to proceed to the next phase of the work, viz., the testing of males belonging to this line. As many males as possible will be tested the coming season. The results of the test will not be completely known until the fall of 1917, since the pullets must make at least a year's record before they can be considered nonbroody.

An examination of the data on the age of pullets when the first egg is laid shows a surprising amount of variability. A number of pullets hatched the same day and kept in one flock throughout the test may range from 195 days of age to over 300 when the first egg is dropped. On the other hand, the correlation between the length of time the bird has been laying and the number of eggs produced prior to March 1 is fairly high, $r = +.8612 \pm .0132$.

The studies on broodiness emphasize the need for one or two pens where the environment can be controlled. The height of the broody season comes during the warm months, but it is not clear whether the large amount of broodiness is due to the temperature alone or to cyclic changes in the birds. If the former, measures might be devised by which the effect of the temperature could be offset.

A marked improvement in the stamina and vigor of the flock has been noted. Probably less than 5 per cent. of the pullets have been thrown out this fall because of lack of vitality.

The data secured this season on hatchability illustrate the desirability of extending such records over long periods of time. In 1914 the average hatchability of hens, compared with their pullet records, showed a marked decrease, nearly all individuals falling below the previous records. In 1915 about equal numbers showed an improvement and a falling off. Apparently the weather conditions exert considerable influence on the hatching quality of eggs. It seems probable that temperature is the determining factor, but until methods of controlling temperature and other environmental factors are available, this point cannot be settled.

A great deal of time has been devoted to artificial brooding. A number of brooders, various methods of brooding, feeding and management have been tried out. Two results of some importance have been secured. First, in general, chicks do better on ground previously unoccupied by poultry than on ground that has been used even for a short time. A very high rate of growth was attained in several lots reared on new land. Second, chicks from certain individuals live and grow much better than from others, just as eggs from some hens hatch much better than those from others.

Equipment.

Sixteen brooding houses 6 by 6 feet have been added to the equipment. These have proven extremely satisfactory for use with the new portable hovers. A thermograph has also been added, which is being used in various places.

DEPARTMENT OF CHEMISTRY.

J. B. LINDSEY.

For convenience the station department of chemistry is divided into the research, fertilizer, and feed and dairy sections.

1. Work of the Research Section.

(*a*) Mr. Beals, under the direction of Dr. Lindsey, has conducted a study of the nutritive value of vegetable ivory meal, including its chemistry, digestibility and value for milk production. Additional experiments by Dr. Lindsey along the same line are still in progress. Although tasteless and tough, this material appears to be quite well utilized by sheep and cows.

Digestion work completed includes a study of cabbages, carrots, pumpkins, soy bean hay and garbage tankage.

(*b*) Dr. Holland and Mr. Buckley have continued their studies in the chemistry of butter fat. The modification of the Hehner and Mitchell method for determining the amount of stearic acid in the insoluble acids of butter fat has been further investigated and a report submitted for publication in the "Journal of Agricultural Research." The method yields a much higher percentage of stearic acid both in butter fat and palm oil than was formerly thought to be present. The method for determining unsaponifiable matter in oils and fats has been perfected. The process is essentially an extraction of the dry soaps with anhydrous ethyl ether, with subsequent purification of the extract.

The stability test with olive oil is now on the sixth year, as it was considered advisable to examine the remaining set of samples in March, 1916, before drawing the work to a close.

The high mortality in the apiaries of the State during the past few years has necessitated the examination in the station laboratory of fifteen samples of dead bees and of comb for arsenical poisoning. The results have been reported to the station apiarist. The demand for an immediate report forced us to devote some time to improvising a method to satisfactorily meet this requirement.

Considerable time was also devoted to the examination of insecticides for other parties, and a number of cases of supposed animal poisoning by arsenicals has been investigated.

(*c*) Mr. Morse, assisted by Mr. Ruprecht, outlines his work as follows: —

Asparagus. — A small amount of analytical work has been performed in finishing some loose ends of samples discovered in sorting and arranging data for publication. A short report on a simple study of the changes in asparagus after cutting proved unexpectedly interesting to the asparagus growers at their annual meeting, and led to a request from their secretary, Wilfrid Wheeler, that the subject be fully studied.

Cranberries. — Analyses have been made of fruit and vines from groups of differently fertilized and unfertilized bogs, with respect to the fertilizing constituents. The samples are unusually uniform in composition by the conventional methods.

Analyses of two lots of Early Black, two of Late Howe and one of McFarlin berries showed also a uniformity in food constituents for the different varieties for this season. Continued study of the bog waters shows the constant presence of a colloid or colloidal mixture, consisting of iron, phosphoric acid, organic matter and a little silica. The bog waters also carry in solution calcium carbonate, arising probably from the concrete in which the tiles are imbedded.

Field A. — Analyses of clover samples, both of tops and of roots, from the most striking plots were made early in the year. Samples of clover at the time of cutting for hay were gathered from each half of each plot in June and again in September, dried and analyzed for nitrogen. The work was done in connection with a proposed study of the effect of liming soil on nitrogen assimilation by crops. The nitrogen determinations were made by Messrs. Beals and Borden in the feed and dairy section.

Mr. Ruprecht continued his study of the minor effects of sulfate of ammonia on the soil, including the formation of soluble manganese compounds and the character of a colloidal substance obtained in soil extracts from the soils dressed with sulfate of ammonia. He also continued his culture work with clover seedlings, using salts of iron, aluminium and manganese with and without calcium carbonate.

Mr. Beals has just begun the study of the comparative effects of muriate and sulfate of potash on the soils of Field B. Especial attention will be given to the effects of the two salts on the content of lime and magnesia.

Tobacco. — During the summer the unusual weather conditions caused many requests for advice concerning tobacco crops. Consequently, considerable time was spent in visiting tobacco fields, looking up meteorological records and the literature on tobacco culture, and making a few soil moisture determinations. Drainage waters from Field A were obtained and were examined, both in their relation to the tobacco problem and to the study of Field A soils.

Soil Problems. — Recently a little time has been spent in an attempt to correlate the numerous soil analyses published in our annual reports, with locality and possible soil formation. Also an attempt has been made to outline a form of procedure which could be followed by county agents when it became necessary, in their judgment, to ask the experiment station for a soil analysis. It appears possible, by utilization of the maps of the United States Geological Survey, the published works on Massachusetts geology, the actual soil surveys made, and analyses on hand, to begin a systematic scheme of soil investigation which would be of use to county agents and would also help when the time comes for a complete soil survey of the State.

2. WORK OF THE FERTILIZER SECTION.

The work of the fertilizer section, in charge of Mr. Haskins, with Messrs. Walker, Jones and Frost as assistants, may be summarized as follows: —

(*a*) *Fertilizers registered.*

During the season of 1915, 112 manufacturers, importers and dealers have secured certificates for the sale of 501 different brands of fertilizer, agricultural chemicals, raw products and agricultural limes, classed as follows: —

Complete fertilizers,	345
Fertilizers furnishing phosphoric acid and potash,	9
Ground bone, tankage and dry ground fish,	51
Chemical and organic nitrogen compounds,	67
Agricultural limes,	29
	501

(*b*) *Fertilizers collected and analyzed.*

During the year 6,914 tons of fertilizer were sampled, necessitating the sampling from 16,709 different sacks. Of the complete fertilizers, 60 per cent. of the total tonnage were high-grade fertilizers (valued over $24 per ton), 31 per cent. were medium-grade (valued between $18 and $24 per ton), and 9 per cent. were low-grade (valued less than $18 per ton).

In this work 150 towns were visited and 1,322 samples, representing 513 distinct brands, were drawn from stock found in possession of 353 different agents.

Seven hundred and twenty-one analyses (505 distinct brands) have been made during the year's inspection, as follows: —

Complete fertilizers,	373
Fertilizers furnishing phosphoric acid and potash,	20
Ground bone, tankage and dry ground fish,	61
Nitrogen compounds,	190
Potash compounds,	7
Phosphoric acid compounds,	34
Lime compounds,	36
	721

Full details regarding the fertilizer inspection work will be found in Bulletin 4, Control Series, published in December, 1915.

In addition to its inspection work this section does considerable work in the analysis of substances sent by different departments of the station and by farmers. It has also found time to conduct experiments to study values of different forms of plant food. A brief outline follows: —

(*c*) *Other Activities of the Fertilizer Section.*

Forty-three brands of commercial fertilizers taken from the 1914 fertilizer inspection were washed out with warm water to obtain a sufficient amount of water insoluble nitrogen for vegetation tests. These were made to study the activity of the insoluble nitrogen and to furnish a comparison with laboratory methods. The water insoluble residues were subsequently analyzed for their total nitrogen, as well as their nitrogen activity, both by the alkaline and neutral permanganate methods. All weights of fertilizing material made in preparation for the vegetation test (140 in number) were made in the laboratory.

Four hundred and ninety-seven different substances have been received and analyzed for farmers, farmers' organizations and the various departments of the experiment station. The materials may be classed as follows: —

Fertilizers and by-products used as fertilizers,	178
Lime products,	27
Soils for lime requirement and organic matter tests,	221
Soils for complete analysis,	2
Soils for partial analysis,	14
Tobacco and onion soils suspected to be suffering from overfertilization, suspected of causing malnutrition of crops,	52
Greenhouse soils suspected to be suffering from overfertilization, suspected of causing malnutrition of crops,	3
	497

Time has been found for considerable co-operative work with the Association of Official Agricultural Chemists. Mr. Walker served as referee on phosphoric acid for the year, planning the work, preparing and sending out samples for analysis, and compiling the final report on this subject for the association.

(*d*) *Vegetation Tests.*

A report of progress only can be made at this time on field experiments begun in 1913 to study the availability of the phosphoric acid contained in basic slag phosphate. There are indications from the yields of oats and buckwheat grown on the soil used in this experiment that the available phosphoric acid has been reduced to such an extent that another year we shall feel justified in making the final experiment.

Two series of pot culture work (44 pots in each series) have been completed to show the availability of phosphoric acid in basic slag phosphate and the raw mineral phosphates as compared with acid phosphate or superphosphate and other soluble phosphoric acid sources. This work is supplementary to the field experiment mentioned above, and is carried on in co-operation with the basic slag committee of the Association of Official Agricultural Chemists. It is planned to continue the work during the coming year. Reports will be made from time to time to the association. The work will also be available for publication by the experiment station if deemed advisable.

A pot experiment begun in the greenhouse last January to study the availability of the water insoluble nitrogen of some of the brands of fertilizer found in the 1914 fertilizer inspection has been completed. This included about 140 pots. Results and conclusions will be found in Fertilizer Bulletin 4, Control Series, published in December, 1915.

3. Feed and Dairy Section.

Mr. Smith was assisted by Messrs. Beals and Borden.

(*a*) *The Feeding Stuffs Law* (*Acts and Resolves for 1912, Chapter 527*).

During the past year 1,043 samples of feeding stuffs were collected by our inspector at 168 different places of business. Over 1,100 brands have been registered and permits for sale issued.

Business conditions, owing to the European war, have been such that the feeding stuff situation has been decidedly abnormal. Cereal grains have ruled high, while the price of many of the cereal by-products, owing principally to the fact that the normal export outlet had been shut off, bore little relation to the price obtained for whole grains. This situation has led to an exceptional opportunity for the use of discretion and intelligence in the purchase of feeding stuffs.

The beginning of what may eventually be an important movement for New England farmers has also been noted in the shipment of California feeding stuffs to New England ports by way of the Panama Canal. Shipments of barley, oats, alfalfa meal, malt sprouts and some molasses feeds have been received. If local freight rates to inland points do not offset the cheap rate for water transportation, this new source of feeding stuffs should prove of benefit.

The results of the year's work of inspection have been published as Control Bulletin No. 3.

(*b*) *The Dairy Law* (*Acts and Resolves for 1912, Chapter 218*).

1. *Examination for Certificates.* — Nineteen applicants have been examined and found proficient.

2. *Inspection of Glassware.* — Four thousand nine hundred and fifty-six pieces of glassware have been tested for accuracy, of which only four pieces were condemned. This is the smallest number condemned in any one year during the fifteen years that the law has been in operation.

Following is a summary for the last fifteen years: —

YEAR.	Number of Pieces tested.	Number of Pieces condemned.	Percentage condemned.
1901,	5,041	291	5.77
1902,	2,344	56	2.40
1903,	2,240	57	2.54
1904,	2,026	200	9.87
1905,	1,665	197	11.83
1906,	2,457	763	31.05
1907,	3,082	204	6.62
1908,	2,713	33	1.22
1909,	4,071	43	1.06
1910,	4,047	41	1.01
1911,	4,466	12	.27
1912,	6,056	27	.45
1913,	6,394	34	.53
1914,	6,336	18	.28
1915,	4,956	4	.08
Totals,	57,894	1,980	3.42[1]

[1] Average.

3. *Inspection of Machines and Apparatus.* — During the month of November, Mr. J. T. Howard, the authorized deputy, has inspected the machines and apparatus in 76 milk depots, creameries and milk inspectors' laboratories. All of the apparatus was found to be in good working condition.

Following is a list of creameries, milk depots and milk inspectors' laboratories visited in 1915: —

1. *Creameries.*

LOCATION.	Name.	Manager or Proprietor.
1. Amherst,	Amherst,	R. W. Pease, proprietor.
2. Amherst,	Fort River,[1]	E. A. King estate, proprietor.
3. Ashfield,	Ashfield Co-operative,	Wm. Hunter, manager.
4. Belchertown,	Belchertown Co-operative,	M. G. Ward, manager.
5. Cummington,	Cummington Co-operative,	D. C. Morey, manager.
6. Easthampton,	Hampton Co-operative,	W. S. Wilcox, manager.
7. Heath,	Cold Spring,	I. W. Stetson, manager.
8. Monterey,	Berkshire Hills Co-operative,	F. A. Campbell, manager.
9. Northfield,	Northfield Co-operative,	C. C. Stearns, manager.
10. Shelburne,	Shelburne Co-operative,	W. C. Webber, manager.

[1] Testing done at the Massachusetts Agricultural Experiment Station.

2. *Milk Depots.*

LOCATION.	Name.	Manager.
1. Boston,	Acton Farms Milk Company,	William Mulcahey.
2. Boston,	Boston Jersey Creamery,	T. P. Grant.
3. Boston,	Deerfoot Farms,	Wm. Johnson.
4. Boston,	Elm Farm Milk Company,	J. K. Knapp.
5. Boston,	Farmers Milk Company,	G. A. Graustein.
6. Boston,	H. P. Hood & Sons,	N. C. Davis.
7. Boston,	Llanwhitkell Farms,	N. C. Cook.
8. Boston,	Morgan Bros.,	A. G. Johnson.
9. Boston,	Oak Grove Farm,	J. Alden.
10. Boston,	Plymouth Creamery Company,	W. J. Gardner.
11. Boston,	Rockingham Milk Company,	L. G. Sanford.
12. Boston,	Turner Center Dairying Association,	C. E. Small.
13. Boston,	D. Whiting & Sons,	J. K. Whiting.

2. *Milk Depots* — Concluded.

LOCATION.	Name.	Manager.
14. Brockton,	Brockton Public Market,	A. R. Greenwood.
15. Cambridge,	C. Brigham & Son,	J. K. Whiting.
16. Everett,	Hampden Creamery,	R. T. Mooney.
17. Great Barrington,	Edgewood Farm Dairy,	C. W. Freeham.
18. Lawrence,	Williardale Creamery,	F. H. Williard.
19. Sheffield,	Willow Brook Dairy,	F. B. Percy.
20. Springfield,	Tait Bros.,	H. Tait.
21. Southborough,	Deerfoot Farms,	S. H. Howes.

3. *Milk Inspectors.*

LOCATION.	Inspector.	LOCATION.	Inspector.
1. Adams,	A. G. Potter.	23. Millbury,	F. A. Watkins.
2. Amherst,	P. H. Smith.	24. New Bedford,	H. B. Hamilton.
3. Arlington,	L. L. Pierce.	25. Newton,	A. Hudson.
4. Barnstable,	G. T. Mecarta.	26. North Adams,	C. T. Quackenbush.
5. Boston,	J. O. Jordan.	27. Northampton,	G. R. Turner.
6. Brockton,	G. Bolling.	28. Pittsfield,	B. M. Collins.
7. Cambridge,	W. A. Noonan.	29. Plainville,	J. J. Eiden.
8. Chelsea,	W. S. Walkley.	30. Revere,	J. E. Lamb.
9. Chicopee,	C. J. O'Brien.	31. Salem,	J. J. McGrath.
10. Clinton,	G. L. Chase.	32. Somerville,	H. E. Bowman.
11. Everett,	E. C. Colby.	33. South Hadley,	G. F. Beaudreau.
12. Fall River,	H. Boisseau.	34. Springfield,	S. C. Downs.
13. Fitchburg,	J. F. Bresnahan.	35. Taunton,	L. C. Tucker.
14. Gardner,	H. O. Knight.	36. Waltham,	C. M. Hennelly.
15. Greenfield,	G. P. Moore.	37. Ware,	F. E. Marsh.
16. Haverhill,	H. L. Conner.	38. Wellesley,	R. N. Hoyt.
17. Holyoke,	D. Hartnett.	39. Westfield,	W. Porter.
18. Lawrence,	J. H. Tobin.	40. West Springfield,	N. T. Smith.
19. Lowell,	H. Marster.	41. Winchendon,	G. W. Stanbridge.
20. Lynn,	H. P. Bennett.	42. Woburn,	D. F. Callahan.
21. Malden,	J. A. Sanford.	43. Worcester,	G. L. Berg.
22. Medford,	W. Joyce.		

4. Miscellaneous.

Location.	Name.	Manager.
1. Boston, ...	Walker-Gordon Laboratory, . .	B. W. Nichols.
2. Boston, ...	United Drug Company, . . .	J. H. Lane, chemist.
3. Somerville, ...	Bushway Ice Cream Company, .	J. Colgan.
4. Springfield, ...	Emerson Laboratory, . . .	H. C. Emerson.

(*c*) *Milk, Cream and Feeds for Free Examination.*

Five hundred and sixteen samples of milk, 1,315 samples of cream, 1 sample of ice cream, 229 samples of feeding stuffs, and 3 samples of vinegar were analyzed. It is preferred that application be made before such samples are sent in order that instructions for sampling and directions for shipping may be sent. Duplicate inspectors' samples of milk will not be examined. While the chemical laboratory, in every way possible, desires to be of use to residents of the State, its resources are limited; hence, it reserves the right to refuse to make analyses where samples are improperly drawn, where the work does not appear to be of general interest or where it would apparently serve no useful purpose.

(*d*) *Testing of Pure Bred Cows for Advanced Registry.*

Four men are given regular employment in conducting Jersey, Guernsey, Ayrshire and Holstein yearly tests. These tests require the presence of a supervisor at each farm where cows are under test for at least two days in each month. Two hundred and fifty cows are now on test, at 37 different farms. Nine of the cows are Holstein, 32 Ayrshire, 69 Jersey and 140 Guernsey. There have been completed during the year 5 Holstein, 45 Ayrshire, 148 Jersey and 178 Guernsey tests.

The Holstein breeders usually test for seven or thirty day periods, and require the presence of a supervisor during the entire test, although there is also a provision for yearly work in the Holstein-Friesian rules. During the year 22 different men have been employed in these shorter tests and 166 seven-day, 36 thirty-day, 5 fourteen-day, and 2 sixty-day tests have been reported. On account of the manner in which the Holstein tests are conducted it is particularly difficult to obtain men always when wanted.

During the early part of the year the work was somewhat handicapped, owing to the presence of foot and mouth disease in the State. We were fortunate, however, in not having a single case on farms visited by our supervisors.

(*e*) *Miscellaneous Work.*

This section also does considerable chemical work in connection with experiments in animal nutrition. A number of samples of milk have been analyzed for the Dairy Department in connection with dairy shows and milk contests. For the station apiarist it has determined the residual beeswax in a large number of samples of slum gum in order to enable him to ascertain the efficiency of different methods for the extraction of beeswax from honeycomb.

4. NUMERICAL SUMMARY OF LABORATORY WORK, DECEMBER, 1914, TO DECEMBER, 1915.

There have been received and tested 90 samples of water, 516 milk, 1,315 cream, 1 ice cream, 229 feedstuffs, 178 fertilizer, 332 soil, 27 lime products, 49 slum gum, 17 samples bees for arsenic, 6 arsenate of lead, 3 vinegar, 58 coal and 21+ miscellaneous.

The fertilizer control work involved the collection of 1,322 and the feed control 1,043 samples. There have also been examined in connection with experiments made by the different departments of the station 209 milks, 132 cattle feeds, 43 fertilizers, 528 millet straw and seed, 255 oat hays, 88 rape plants, 4 soy bean hays, 1 alfalfa and 1 buckwheat hay. The above totals 6,468 samples, and does not include the work of the research section nor the work under the dairy law.

DEPARTMENT OF BOTANY.

A. V. OSMUN.

The botanical work of the experiment station during 1915 has been along lines previously reported. Diagnosis of plant diseases, seed separation, germination and purity tests, and resultant correspondence have required much time and attention. While the responsibility for these activities has always been assumed by the experiment station, it would seem that the time must soon come when such work will be done by members of the staff paid from extension service funds. Service work of this sort does not legitimately belong to men employed for research, and it seriously inhibits progress on their research projects.

Several diseases not previously noted as occurring in the State were reported. These are mosaic of sweet pea; ringspot of cauliflower, caused by *Mycosphærella brassicæcola* (Duby) Lindau;[1] and a leaf spot of digitalis, caused by an undetermined species of colletotrichum.

Silvery scurf of potatoes, first reported from this State in 1914, appeared in several new localities during the last year.

The summer of 1915 was notable for its large number of cloudy days and heavy rainfall, and the relative humidity during July and August was considerably above normal. Such conditions are ideal for the development of fungous diseases of plants, and crop losses from this source were exceedingly heavy. The number of complaints and entailed correspondence were proportionately larger than usual.

Among the diseases most frequently reported were late blight of potato, rhizoctinia stem rot of potato, downy mildew of cucumber and melon, anthracnose of cucumber, sooty blotch of apple, brown rot of peach, plum and cherry, leaf curl of peach, downy mildew of grape, anthracnose of bean, bacterial blight of bean, late blight of celery, tomato scab, botrytis stem and bud rot of peony, rust of antirrhinum, chestnut canker and anthracnose of sycamore.

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[1] Osmun, A. Vincent, and Anderson, P. J. Ringspot of Cauliflower. In Phytopathology, 6, p. 260, 1915.

The damage to the potato crop due to the late blight was especially heavy throughout the State. It was noticeable, however, that on those fields repeatedly sprayed with Bordeaux mixture comparatively little loss resulted. While spraying is quite generally practiced by potato growers, there is a tendency to be satisfied with one or two applications, whereas in such a season as the last the applications should be made at intervals of ten to fourteen days throughout the growing period of the vines.

It is noteworthy that downy mildew of cucumbers was reported in greenhouses in the eastern part of the State as early as May first, which was fully a month earlier than this disease usually makes its appearance. It continued to cause serious damage during the entire summer, and was present in some houses long after the first fall frosts. It resulted in total failure of the cucumber crop in some places, and heavy loss resulted everywhere, both to indoor and outdoor crops. A similar outbreak of the disease occurred in 1913.

In the past some concern has been felt over the possibility that powdery scab of the potato might be introduced into the State. In order to obtain evidence regarding the ability of the powdery scab organism to cause the disease in this State, the department undertook to test the matter in co-operation with the United States Department of Agriculture. Experimental plantings of infected tubers in two-foot tile filled with soil from station plots failed to produce any tubers showing the slightest evidence of powdery scab. On the other hand, diseased tubers were produced in soil from the same source sent to Maine for the purpose of investigation. This evidence, coupled with similar results obtained in other eastern States, while not conclusive, suggests the probability that powdery scab will not become a troublesome disease of the potato in Massachusetts, and that climatic conditions play an important part in its distribution.

Heavy losses to the tobacco growers of the Connecticut valley resulted from obscure troubles not yet determined, but evidently of a physiological character in some way related to nutrition.

The white pine blister rust, which for several years has been known in a few restricted areas of the State, was last year discovered in eight of the fourteen counties of the State. In the western part of the State the outbreak of the disease has assumed alarming proportions. In consequence of the increasing seriousness of the situation the department has undertaken the investigation of certain phases of the life history of the causal fungus, with a view to working out some means of control.

Satisfactory progress has been made on all old projects. The following new projects were submitted during the year: —

5. Investigation of tobacco diseases in Massachusetts.
6. Investigation of white pine blister rust.

DEPARTMENT OF ENTOMOLOGY.

H. T. FERNALD.

The work of the department has progressed satisfactorily during the past year. Correspondence has, as usual, taken considerable time, and the insects involved have been of many kinds.

The largest number of inquiries received has been about plant lice, and scale insects have come next in order. The red spider has been the subject of numerous letters, and methods for the control of ants, the gypsy and brown-tail moths, tent caterpillars, bean weevils, root maggots, white grubs, cutworms, grasshoppers and the rose bug have frequently been requested.

Some unusual subjects of correspondence have been with reference to borers in furniture, the iris borer and fleas. Maggots of the screw-worm (*Compsomyia macellaria* Fab.), taken from a human ulcer, have been received, and lady beetles were sent in, captured, it was stated, feeding on tent caterpillar larvæ.

The strawberry crown girdler (*Otiorrhynchus ovatus* L.) appeared last spring in enormous numbers in a forest nursery in the State, causing an estimated loss of over $15,000. Its work was first noticed in beds of two-year-old white pines, the tops of the plants turning brown. Examination showed that the larvæ had girdled the stems and roots of the plants at from one to three inches below the surface of the ground. The trouble was reported to this department on the 13th of May, and a visit to the infested areas was made on the 15th. At that time entire beds of the trees, perhaps ten feet in width by thirty or forty in length, were without a living tree, and as these were in rows about three inches apart and about an inch apart in each row, the number of dead trees was very great. The pines in these beds were about six inches high. Quite a large number of beds were in this condition and others were more or less affected, while larger trees in blocks also showed considerable infestation. It was noticed that the attack was most severe on the higher parts of the land which, though approximately level, varied six or eight feet perhaps from the lowest to the highest points, and that the soil of these higher portions was lighter and more sandy than on the rest of the area. In many cases a spread from a completely infested bed to those adjoining was evident, the space between being in most cases not over a foot in width. White pine was not the only variety attacked, injury to the red pine, Scotch pine, Juniperus virginiana, blue, Douglass and Norway spruce, and even to sugar maple seedlings of the two-leaf age being very evident, and in many cases severe.

At the time of the first visit the larvæ were evidently nearly mature, and most of them pupated within two weeks thereafter. Beetles were appearing by the middle of June, and were at their maximum abundance about the seventh of July.

The eggs proved very difficult to discover, but a few were observed before the end of July and a few larvæ appeared later, but owing to the impossibility of continued field observations after the end of that month the further history of the insect during the season was not followed. The superintendent of the nursery, however, carefully watched for larvæ all through the season, but found few. These were in some cases observed late in the fall.

From the evidence thus far at hand it would seem that in this infestation at least some portion of the larval feeding was in the fall and was resumed in the spring, and also that the adult period of life of the insect extended over several months. It is hoped that if the outbreak is still in progress in 1916 further studies of the life history of the insect can be made.

At the time of the first visit to the nursery it was evident that pupation would soon take place, and it was, therefore, advised that the beds affected be entirely stripped of all plants and thoroughly cultivated every two or three days, both in order to remove all food from the larvæ and to break up the pupal cells formed at pupation. Examination of beds thus treated afterwards showed numerous dead pupæ, but also indicated that some larvæ, at least, pupated lower than a harrow would reach, and plowing once or twice to reach the more deeply placed pupæ was also suggested.

Later, when the beetles emerged, trapping methods were resorted to with considerable success. Boards, burlap and weed piles placed in the rows between the beds all gave their quota of beetles, but the weed piles proved most effective, more being taken under them than under boards and burlap together. The traps were most effective during hot, dry weather, few being taken under them on cloudy, damp days.

To prevent the insects from laying their eggs near unaffected trees in the blocks, the ground immediately around the stems was heavily sprayed with one pound of whale-oil soap in four gallons of water; with kerosene emulsion; and with Black-leaf 40 in different parts of the nursery, in the hope that these materials would act as repellants. It was also advised that the beds cleared of plants be not reset until after the adult beetles had disappeared, so that there should be no inducement for egg-laying there. The results of these treatments cannot be determined with any certainty before the spring of 1916.

During these investigations Dr. Hopkins of the Section of Forest Insect Investigations of the United States Bureau of Entomology, and one or two of his assistants also visited the nursery, and the recommendations for treatment were gone over and considered by them also, the two offices co-operating in the investigation.

All the regular lines of investigation have been continued, and it is believed that with the season of 1916 some may be completed and attention given to other problems awaiting study. Progress in them all has been as satisfactory as could be expected when the amount of time available for the purpose, with the working force provided, is taken into consideration. At the present time this working force is about equivalent to the entire time of one man, who must attend to the station correspondence; conduct all the rearing of specimens sent in as causing trouble which cannot be identified in the stage in which they are received; apply several thousand sprays under varying temperatures and humidities to eight or ten different kinds of trees at some distance from headquarters, and visit them three or four times on succeeding days to ascertain results; give various experimental treatments for insect control to plants, often a considerable distance from his office and source of supplies; visit plants of certain kinds to ascertain at just what time of year certain insects on them change into other stages where control can be effective; and, finally, to keep full records of all this work and bring the results into shape for permanent preservation and publication. With such a list of duties (and this is by no means complete) large results speedily obtained can hardly be expected.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

A. E. CANCE.

Two lines of work were authorized by the experiment station committee: one an investigation into agricultural insurance, to be carried on largely by correspondence with other States, and the other an investigation into the cost of distributing onions or tobacco, or both.

Regarding agricultural insurance, requests were sent to several States in the Union in the endeavor to ascertain the amount and kind of agricultural insurance that was written in these States. The results of this inquiry have not been tabulated, but in general we find, first, that there is little or no live stock insurance except insurance on race horses or on high-grade exhibition stock when shipped to shows. There are two or three mutual companies doing a little along these lines, but they have few precedents to guide them, and are still in the dark as to the amount of premiums or the possible losses.

Very little livestock insurance is written in New England. Three companies, two in New England and one in Illinois, are engaged in the business of insuring animals. Their rates are high, 10 per cent. per annum, — too high for the average farmer. There is a third company which has recently entered this field in New England, and which, consequently, lacks experience. It insures stock against both disease and accident. Owing to certain peculiarities in the laws of Massachusetts, it can do only a casualty business in this State. This company insures packing house cattle on the way to market, and reports it has been picking up a good business in this line, especially on the stock shipped to the Boston packing houses.

Hail insurance of tobacco is also a comparatively recent development in agricultural insurance, although it is much better known in New England than live stock insurance. A number of companies write this insurance, charging a rate of 5 per cent. whatever the period of insurance. Despite the high rate, the growers are availing themselves of this protection rather generally, and, apparently, are very well satisfied with the services rendered. For this sort of insurance the year 1915 was very disastrous, especially to those companies whose business is confined to local territory. The amount of the hail insurance policy is limited to the cost of growing the crop, and adjustments of losses are made on this basis. The farmer may take out insurance for $100, $150 or $200 per acre. If the crop is one-half insured he receives one-half insurance, etc.

Second, as to methods and cost of distributing onions in the Connecticut valley. One or two men have been employed on this investigation, practically from July to December. The investigation of the production and distribution of Connecticut valley onions is practically completed and the bulletin will be issued soon.

The first part of the investigation shows the growth and extent of the onion industry in the United States and Massachusetts, and the place of the Connecticut valley onion in the commercial onion-growing belt. It also describes briefly the method of culture and some of the specific problems confronting the onion grower.

The second part deals with the problems of distribution, preparation for market, storage and transportation. The data collected cover at least two full seasons and are complete enough for comparative studies of acreage, yield, cost of production, cost of handling, storage, shrinkage, competition in the principal markets, periods of shipments and prices.

Data for the year 1914 show that 8 towns in Franklin County and Hampshire County had an onion acreage of 3,965, which yielded approximately 1,900,000 bushels. Of this, 60 per cent. was marketed directly from the field or temporary storage before November 4; the other 40 per cent. was kept in storage for later sale. Practically all the onions are out of the farmers' hands by Thanksgiving.

There are some thirty onion storages in the valley, with a capacity of about 600,000 bushels. Shipments from these begin about December 1, but are heaviest in March. To produce and market a bushel of onions costs from 36.6 to 40.6 cents. The cost of storage, including shrinkage (6.6 cents), to the local storage man is about 14.6 cents per bushel. Rented storage costs 14 cents per 100 pounds if the farmer does his own work, and 25 cents per 100 pounds if the storage man does all the work after the onions are delivered at his warehouse. At least 75 per cent. of the total crop is bought by eight dealers. The chances for gain by holding onions in storage are good in view of the fact that a four-year average (1911–15) shows that the March price was 51 per cent. higher than the September and 61 per cent. higher than the October price.

Connecticut valley onions are shipped to all the principal markets of New England. A large number go to Canada and the Middle States, especially New York, Maryland, and Pennsylvania as far west as Pittsburg. Still others, because of special transportation rates and superior quality, compete successfully with the Ohio muck onions in the leading markets of the south.

DEPARTMENT OF METEOROLOGY.

J. E. OSTRANDER.

During the past year the work in meteorology has followed largely along the lines of former years. The various weather phenomena have been systematically observed and the records carefully arranged for ready reference. The several self-recording instruments have been kept in working order and their records transcribed in the yearbook for permanent preservation.

A summary of the more important records has been published each month in a monthly bulletin, with such comments on the general character of the weather as seemed called for by a comparison with the normals for this station.

The co-operation with the United States Weather Bureau has continued throughout the year, and their forecasts have been received and the proper signals displayed from the flagstaff on the tower. The special weekly snow reports are being furnished the Boston office this year as heretofore.

Numerous inquiries regarding the weather conditions on certain dates have been received from farmers, scientific investigators, shippers and others, and in practically all cases we have been able to furnish the data called for.

BACILLARY WHITE DIARRHEA (BACTERIUM PULLORUM INFECTION) IN YOUNG CHICKS IN MASSACHUSETTS.

By G. EDWARD GAGE and BERYL H. PAIGE

(Department of Veterinary Science)

Massachusetts Agricultural Experiment Station.

Purpose.

The object of this paper is to set forth the facts concerning bacillary white diarrhea of young chicks, together with a discussion concerning its cause, distribution, diagnosis and economic importance in the State of Massachusetts. It includes, also, the results obtained from the work of the Department of Veterinary Science in applying the macroscopic agglutination test as a means of detecting adult hens which may be the source of infection.

Brief History of Disease.

In 1900 Rettger[1] reported a peculiar ailment of hen-hatched chicks, and isolated from the liver and spleen an organism, pure cultures of which, when inoculated into healthy chicks, resulted in a reproduction of the disease; he was able to recover the organism from the internal organs of the dead chicks. In 1901 he[2] again reported a serious epidemic occurring on three adjoining farms and involving hundreds of chicks, all of which were hen-hatched. About 80 per cent. of the total flocks died, all exhibiting symptoms similar to those of the first epidemic. The organism was isolated, and inoculation experiments were again successful.

In 1908 Rettger and Harvey,[3] and in 1909 Rettger[4] alone, reported work carried on in connection with other epidemics showing that the organism was recovered and the disease successfully reproduced. They also described the details of attempts to transmit the disease. At this time the organism was designated *Bacterium pullorum.*

In 1909, after having carried on extensive co-operative experiments with Professor Stoneburn at the Storrs Agricultural Experiment Station,[5] it was found that the original source of the infection was the hen. Eggs from infected hens contain the organism in the yolks; chicks produced from infected eggs have the disease when hatched. The disease may be spread through the medium of infected food and water.

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[1] Rettger: "Fatal Septicemia in Young Chicks." New York Medical Journal, Vol. LXXI., 1900, p. 803.

[2] Rettger: "Fatal Septicemia in Young Chickens." New York Medical Journal, Vol. LXXIII., 1901, p. 267.

[3] Rettger and Harvey: "Fatal Septicemia in Young Chickens or White Diarrhea." Journal of Medical Research, Vol. XVIII., 1908, pp. 277-290.

[4] Rettger: "Further Studies on Fatal Septicemia in Young Chickens or White Diarrhea." Journal of Medical Research, Vol. XXI., 1909, pp. 115-123.

[5] Rettger and Stoneburn: "Bacillary White Diarrhea of Young Chicks," Bulletin No. 60, Storrs Agricultural Experiment Station.

In 1911 Gage[1] thoroughly investigated the matter of *Bacterium pullorum* infection and fully substantiated the work of Rettger and Stoneburn already cited, — that "white diarrhea," as poultrymen understand it, is a bacillary disease caused by *Bacterium pullorum*, and that the hen is the original source of infection, transmitting the organism from the ovary to the eggs. At that time the author, from the material received at the laboratory, concluded that most of the white diarrhea of chicks is bacillary white diarrhea, caused by the same organism isolated by Rettger and designated *Bacterium pullorum.*

Jones [2,3] also concluded that *Bacterium pullorum* produced fatal septicemia or bacillary white diarrhea in young chicks; and that they are most susceptible during the first twenty-four hours of life. *Bacterium pullorum* was found in the egg.

From the work of these investigators the conclusions are justifiable that *Bacterium pullorum* can produce a white diarrhea; the hen is the original source of infection; and that the disease may be transmitted from the ovary to eggs for hatching. The carrier problem thus is one of great importance. The question also arises as to how ovarian infection may be brought about. Experiments[4] were conducted for three years at the Storrs Experiment Station concerning this point, and one question which was answered positively by the results of this work and substantiated here in Massachusetts was, "Do chicks which survive an attack of bacillary white diarrhea become permanent carriers of the disease?" The results here at the Massachusetts Agricultural Experiment Station, and those from the experiment station at Storrs, are very decisive, and demonstrate that pullets infected as chicks may become permanent bacillus carriers. The three plates accompanying show graphically the cycle of infection, and picture normal and infected ovaries.

At this time it is important to state that in substantiation of the work of the Connecticut station on this point this department has been successful in several instances in isolating *Bacterium pullorum* from eggs laid by a Silver Penciled Wyandotte, the sole survivor of a large number of day-old chicks which were submitted to *Bacterium pullorum* infection.

Jones[5] suggested and used successfully an agglutination test for detect-

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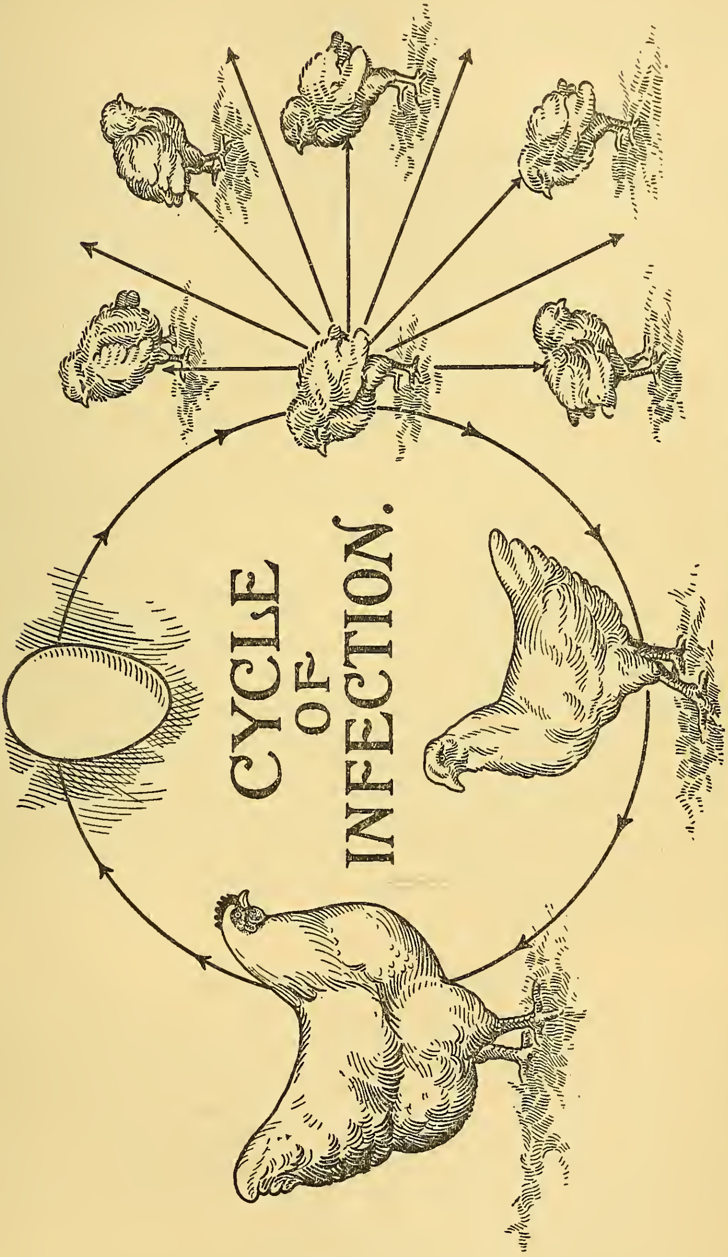
[1] Gage: "Notes on Ovarian Infection with *Bacterium pullorum* (Rettger) in the Domestic Fowl." Journal of Medical Research, Vol. XXIV., No. 3 (New Series, Vol. XIX., No. 3), pp. 491-496, June, 1911.

[2] Jones: "Annual Report of the New York State Veterinary College," Ithaca, N. Y., 1910, p. 111.

[3] Jones: "Annual Report of the New York State Veterinary College," Ithaca, N. Y., 1910-11, p. 69.

[4] Rettger, Kirkpatrick and Jones, R. E.: Bulletin No. 77, Storrs Agricultural Experiment Station.

[5] Jones, F. S.: Journal of Medical Research, Vol. XXVII., No. 4 (New Series, Vol. XXII., No. 4), pp. 481-495, March, 1913.



Reproduced from diagram (from Bulletin No. 68) showing how bacillary white diarrhea perpetuates itself in the breeding stock. (By courtesy of the Storrs Agricultural Experiment Station, Storrs, Conn.

ing this infection. Gage[1] and Rettger[2] have also used and applied it with good results, both in diagnosing the infection and as a basis for control and eradicating the infection from breeding flocks.

ESTABLISHMENT OF METHODS FOR DETECTING CARRIERS OF THE DISEASE.

Since it has been shown conclusively by the workers quoted above that infected ovaries constitute the real source of infection in bacillary white diarrhea of chicks, the basis of prevention rests to a great extent upon this significant fact. Then, too, the work already cited has exhibited the scientific proof which shows that chicks surviving an attack of bacillary white diarrhea may become permanent carriers.

Attempts have been made to apply various tests for locating this infection in adult hens, but the macroscopic agglutination test, as noted above, which is discussed later in this paper, has proven reliable and practical for testing the blood of mature stock. The results reported in Bulletin No. 148 of this station, together with those reported from Cornell and Connecticut, demonstrate that the value of the macroscopic agglutination test can no longer be doubted. It furnishes a practical method of diagnosing infection in adult hens. It is inexpensive and reliable, and up to the present time nothing has occurred to detract from the merits of the test. In the hands of properly qualified persons, and carried out under observation of the laws of pathology, both from the standpoint of the study of disease and eradication of disease, as indicated by our records to date, it is fast proving to be more and more valuable as a means of detecting birds which may be a source of infection to young day-old chicks.

Therefore, with this consideration, nothing should stand in the way for proper authorities to make it possible for the present workers in this field to continue this important work and apply the test extensively throughout Massachusetts, and aid in ridding breeding flocks throughout the State of these permanent carriers of *Bacterium pullorum*. Backed by our present data from the laboratory, this work could be carried on with every promise of success.

INFECTION IN MASSACHUSETTS.

The establishment of such important facts in regard to bacillary white diarrhea as its cause, original source, and mode of transmission, and the perfection of a test which is able to detect the sources of the disease, are subjects which have been referred to in an earlier part of this paper. The question which confronts the poultryman of Massachusetts is, "Does bacillary white diarrhea exist to any extent in Massachusetts?" In reply to this question we set forth the data that we have obtained up to date, as well as the methods used in procuring them.

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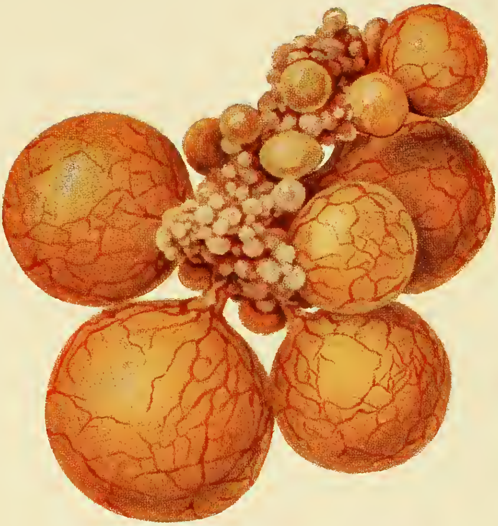
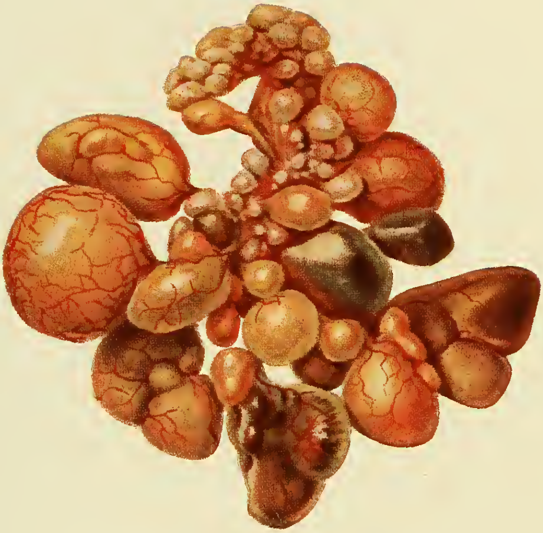
[1] Gage: "On the Diagnosis of Infection with *Bacterium pullorum* in the Domestic Fowl." Massachusetts Agricultural Experiment Station, Bulletin No. 148, April, 1914.

[2] Rettger: Storrs Agricultural Experiment Station, Bulletin No. 77, June, 1914, p. 272.



NORMAL OVARY

Reproduced from Storrs Agricultural Experiment Station, Bulletin 77, Storrs, Conn.



INFECTED OVARY (*B. pullorum*)

Reproduced from Storrs Agricultural Experiment Station, Bulletin 77, Storrs, Conn.

METHODS USED IN LOCATING AND ERADICATING INFECTION.

As the presence of *Bacterium pullorum* infection in a flock is strikingly indicated by the death of a large number of young chicks, it is to be expected that the location of the disease can be readily determined by the examination of chicks which have died. It is by this means that we have obtained data in regard to most of the infected areas in the State. In two cases, however, the flock owners, believing from their chick losses that bacillary white diarrhea existed in their flocks, asked to have their adult birds tested without sending chicks for preliminary examination. Results of the agglutination tests gave proof that the disease was present in these flocks.

METHODS USED IN EXAMINATION OF CHICKS.

In examining dead chicks which have been received in the laboratory the following procedure is employed: The general appearance of chicks when they are received is noted. Each chick is numbered and that number recorded, so that individual records are kept on the examination of each bird. They are then pinned, by wings and feet, ventral side upward, to a sterile dissecting board, the feathers are removed by singeing with a gas flame, and the abdominal and thoracic organs exposed by cutting through the walls of these cavities. At this time any internal pathological features — *i.e.*, the color of liver, size, consistency and color of the unabsorbed yolk (if present), appearance of the ceca, etc. — are noted. Employing the usual methods to prevent outside contamination, tubes of sterile agar-agar are inoculated with material from such organs as the heart, liver, unabsorbed yolk and intestinal tract, and the tubes are allowed to stand in the incubator at 38° C. until sufficient time has elapsed to insure the growth of *Bacterium pullorum*, if present. Material in all tubes is then carefully examined for this organism and the findings recorded. When *Bacterium pullorum* is found, a culture of it is retained in the laboratory under an individual retention number, and thus may be used for future reference.

Since February of this year our records show that between 700 and 800 chicks, the majority of them dead, have been received for examination. In some cases, however, live ones have come for observation, and these have been placed under favorable conditions and given the food best suited to their ages. Any that died have been examined according to the method given above.

SUMMARY OF DATA SECURED BY CHICK AUTOPSIES.

To summarize briefly the areas in the State in which the above method has shown that infection exists we refer to Map I. As we mentioned before, all localities showing infection, with the exception of two flocks in which the presence of the disease was detected by the agglutination test, have been determined by the examination of dead chicks.

The Agglutination Test.

While the macroscopic agglutination test is of service in the location of bacillary white diarrhea infection, its greatest importance lies in the part it plays in the eradication of this disease by detecting in a breeding flock adult birds which are acting as carriers of the organism *Bacterium pullorum*.

In spite of the fact that a detailed account of this test for the detection of adult birds which are harboring or have harbored *Bacterium pullorum* infection has been presented in an earlier bulletin (Gage, Geo. Edward: Bulletin No. 148, 1914, Massachusetts Agricultural Experiment Station. "On the Diagnosis of Infection with *Bacterium pullorum* in the Domestic Fowl"), we wish to review briefly the important points of the method, especially in relation to the work carried on during the last few months.

As the reader of our earlier bulletin will remember, the two important biological factors necessary for making the macroscopic agglutination test are (1) a test fluid containing a suspension of the organism causing the disease *Bacterium pullorum*, and (2) a sample of blood serum from the individual to be tested, and the test is based on the fact that the blood sera of infected and non-infected birds when mixed with the test fluid react differently. The serum of the former, because of the presence of an agglutinin, a substance formed in the body of the bird because of infection with *Bacterium pullorum*, is capable of producing, when brought in contact with a suspension of the organism, a clumping together of the bacteria, a phenomenon which blood from non-infected birds does not show.

Test Fluid.

As earlier experiments have shown that a polyvalent test fluid is better suited for laboratory routine than a monovalent one (Bulletin No. 148, pp. 15, 16), we selected for our work the following strains of *Bacterium pullorum:* —

Strain 1. — Isolated March, 1914, from chick received from central Massachusetts.

Strain 2. — Isolated summer of 1913 from chick inoculated experimentally with *Bacterium pullorum* isolated from egg from eastern Massachusetts.

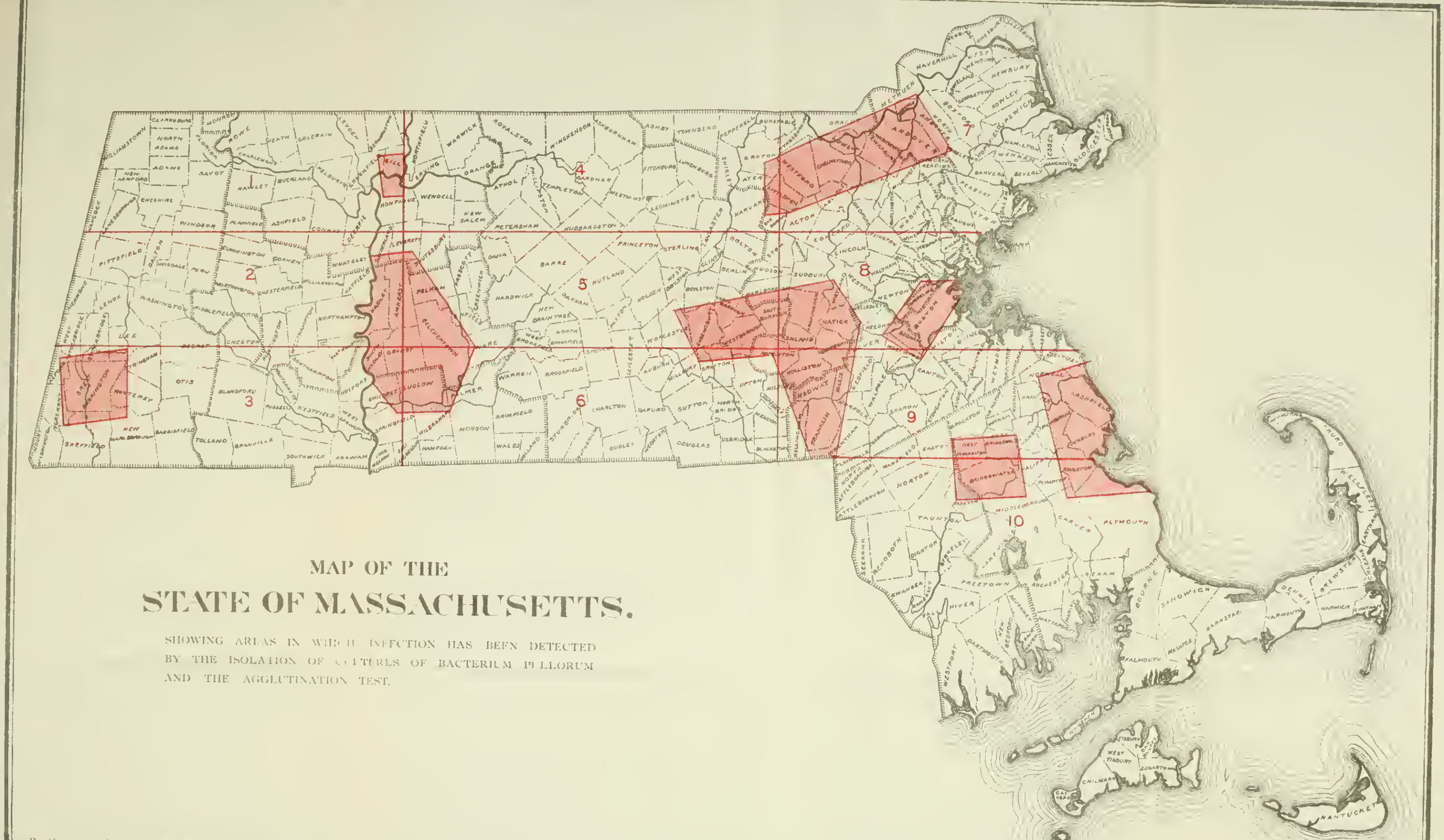
Strain 4. — Isolated from chick from eastern Massachusetts.

Strain 5. — Original strain of *Bacterium pullorum,* isolated 1911 from chick in Maryland.

Strain 6. — Isolated spring of 1914 from Massachusetts material sent to laboratory.

These gave us representative cultures from several localities, and all test fluids have been mixtures of four or all these strains.

These cultures were studied to make sure of their purity, grown in large quantities on agar-agar at a temperature of 38° C., and the growth washed off in a carbolated sodium chloride solution (0.85 per cent. NaCl solution,



MAP OF THE

STATE OF MASSACHUSETTS.

SHOWING AREAS IN WHICH INFECTION HAS BEEN DETECTED BY THE ISOLATION OF CULTURES OF BACTERIUM PULLORUM AND THE AGGLUTINATION TEST.

By Courtesy of State Department of Health.

1 per cent. glycerine, 0.5 per cent. phenol). The resulting cloudy fluid was then well shaken, filtered through cotton, tested and preserved on ice. In case any bottle of test fluid was not used immediately it was retested before using it for diagnostic purposes.

Methods of drawing and treating Blood Samples.

In drawing blood samples from the birds tested we have found it convenient to make use of some sort of improvised table upon which the birds can be laid; and, at the same time, small collecting tubes, absorbent cotton and carbolic acid can be arranged within easy reach.

The hen is laid on her back on the table, with one wing projecting over the edge; the feathers are quickly removed from a small area on the underside of the wing, so that the course of the wing vein may be seen clearly, and the region washed with absorbent cotton wet with 2.5 per cent. carbolic acid. With scissors, or a sharp knife, a cut is then made in the vein near the outer bend of the wing, which is slanted in such a way that the blood flows directly into small sterile tubes. After a small amount (2 to 3 cubic centimeters) has been collected the cut is washed again with carbolic acid, and fresh, dry absorbent cotton is pressed against the wound to check the flow of blood. With the cotton still under the wing the bird is placed gently on the floor of the pen, and, in most cases, there is no trouble with further bleeding. In the few instances where the blood has not ceased flowing immediately additional pieces of absorbent cotton, pressed over the incision and left under the wing, have been sufficient to stop bleeding. The tube in which the blood has been collected is then plainly marked with the number of the hen from which it came, tightly corked and set away to clot.

After all samples are collected from the flock the tubes of blood are taken to the laboratory and set on the ice until the clots are well formed. They are then removed from the sides of the tubes and broken up by means of sterile brass strips, one of which is in each collecting tube. After removing the brass strips it is customary to place the samples again on ice over night. By morning the serum appears in appreciable quantities above the clot, and, after centrifugalizing the contents of each tube, it may be easily pipetted from the collecting tube into a sterile bottle in which it is diluted 1–20 with sterile 0.85 per cent. salt solution, and kept on ice until needed for further work.

Making the Agglutination Test.

For these tests small test tubes 100 millimeters long and 10 millimeters caliber have been employed. In the majority of cases three tubes have been used for each individual tested, two of the tubes containing 1.5 cubic centimeters test fluid and the third, 1.5 cubic centimeters carbolated salt solution for a control. In tube No. 1 has been placed 0.3 cubic centimeters diluted blood serum, making a final dilution of serum, 1–100;

in tube No. 2, 0.15 cubic centimeters serum (final dilution 1–200), and in tube No. 3, 0.3 cubic centimeters diluted serum. In some cases a third tube of test fluid has been used with a 1–500 dilution of serum. All tubes have been labelled with hen numbers, dilution of serum contained, and shaken to afford thorough mixing of the test fluid and serum. In each set of tests one tube containing test fluid alone has been placed as a second means of controlling the results. At this point the tubes have been set in the incubator at 38° C., and readings have been made at the end of twenty-four, forty-eight and seventy-two hours.

In tests made on infected flocks readings of the tubes showed that in some containing test fluid and serum, fine, flakelike masses had settled to the bottom and sides, leaving the supernatant fluid clear. In other tubes the mixture of test fluid and serum remained hazy as it was at the time tests were set up, and no flaky sediment appeared. In the first case it is evident that the serum contained an agglutinin which had caused the agglutination of the bacteria of the test fluid, and all birds with sera reacting in such a way have been reported as positive reactors.

For all flocks tested record cards of all details have been filed, the material including, in addition to records of hen numbers and all readings of tubes, such data as date of drawing of blood samples, date same have been received in laboratory, their condition, and notes on the test fluid. From these records, at the conclusion of the tests, a complete report can be sent to the owner of the flock. In these reports a list of the numbers of all hens tested has been sent, the numbers of positive reactors being preceded by a red star. Together with this list has been sent a recommendation to be followed in the eradication of infection from the flock. In addition to the above data the laboratory record cards include data received from the owner concerning the results he has attained from tested stock.

Data secured from Agglutination Tests.

In organizing for publication the data gained up to the present time from our work with the agglutination test it has seemed wise to divide a map of the State of Massachusetts into districts, and, using these districts as units, to make a chart showing the results of the agglutination tests on representative flocks in these areas.

This chart gives the number of the district from which the flock has been chosen, — this number corresponding to number of district on map, — the laboratory number of each bird, owner's number of bird, results of the tests in dilutions 1–100 and 1–200 (— indicates a negative, + a positive reaction), total numbers of individuals tested in flock, number reacting positively, and percentage of positive reactors. In this way it will be possible for poultrymen in the various districts to get complete data from representative flocks.

Chart showing Results of Agglutination Tests for Bacterium Pullorum Infection in Blood of Breeding Flocks. These are Representative Flocks chosen from Districts of Massachusetts.

District 1.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
3- 1	2	—	—			
3- 2	3	+	+			
3- 3	8	+	+			
3- 4	10	+	+			
3- 5	12	−	−			
3- 6	13	+	+			
3- 7	*13	+	+			
3- 8	15	+	+			
3- 9	16	−	−			
3- 10	*16	−	−			
3- 11	17	−	−			
3- 12	18	−	−			
3- 13	21	−	−			
3- 14	22	+	+			
3- 15	23	−	−			
3- 16	24	−	−			
3- 17	25	−	−			
3- 18	27	+	+			
3- 19	28	−	−			
3- 20	29	+	+			
3- 21	30	+	+			
3- 22	31	+	−			
3- 23	35	+	+			
3- 24	37	−	−			
3- 25	38	+	+			
3- 26	39	+	+			
3- 27	42	+	+			
3- 28	43	−	−			
3- 29	44	+	+			
3- 30	45	+	+			
3- 31	*45	+	+			
3- 32	46	+	+			
3- 33	47	+	+			
3- 34	49	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 1 — Continued.

Laboratory Number.	Hen Number.	AGGLUTINATION TEST.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
3- 35	50	+	+			
3- 36	51	−	−			
3- 37	52	+	+			
3- 38	53	+	+			
3- 39	54	+	+			
3- 40	57	+	+			
3- 41	58	−	−			
3- 42	61	+	+			
3- 43	62	+	+			
3- 44	65	−	−			
3- 45	67	+	+			
3- 46	69	+	+			
3- 47	70	+	+			
3- 48	71	−	−			
3- 49	72	−	−			
3- 50	74	−	−			
3- 51	75	−	−			
3- 52	76	−	−			
3- 53	77	+	+			
3- 54	79	+	+			
3- 55	80	+	+			
3- 56	82	+	+			
3- 57	84	+	+			
3- 58	85	+	+			
3- 59	86	+	+			
3- 60	87	−	−			
3- 61	89	−	−			
3- 62	91	−	−			
3- 63	92	+	+			
3- 64	93	−	−			
3- 65	94	+	+			
3- 66	97	−	−			
3- 67	100	+	−			
3- 68	101	+	+			
3- 69	102	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 1 — Continued.

Laboratory Number.	Hen Number.	AGGLUTINATION TEST.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
3- 70	103	–	–			
3- 71	104	+	+			
3- 72	106	+	+			
3- 73	115	+	+			
3- 74	118	–	–			
3- 75	124	–	–			
3- 76	125	–	–			
3- 77	*125	–	–			
3- 78	128	–	–			
3- 79	129	–	–			
3- 80	131	–	–			
3- 81	132	–	–			
3- 82	133	–	–			
3- 83	134	+	+			
3- 84	135	–	–			
3- 85	136	–	–			
3- 86	137	–	–			
3- 87	138	–	–			
3- 88	140	–	–			
3- 89	141	–	–			
3- 90	142	+	+			
3- 91	143	–	–			
3- 92	144	–	–			
3- 93	146	–	–			
3- 94	147	+	+			
3- 95	148	+	+			
3- 96	149	–	–			
3- 97	*149	–	–			
3- 98	150	+	+			
3- 99	151	+	+			
3-100	152	–	–			
3-101	153	+	–			
3-102	154	–	–			
3-103	155	+	–			
3-104	156	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 1 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
3-105	157	−	−			
3-106	159	−	−			
3-107	160	−	−			
3-108	161	−	−			
3-109	162	+	+			
3-110	163	+	+			
3-111	164	−	−			
3-112	165	+	+			
3-113	167	−	−			
3-114	168	−	−			
3-115	169	+	+			
3-116	170	−	−			
3-117	171	−	−			
3-118	172	−	−			
3-119	174	+	−			
3-120	175	+	−			
3-121	176	−	−			
3-122	177	−	−			
3-123	178	−	−			
3-124	179	+	+			
3-125	180	−	−			
3-126	182	+	+			
3-127	183	−	−			
3-128	184	−	−			
3-129	186	−	−			
3-130	187	+	+			
3-131	188	+	+			
3-132	189	+	+			
3-133	191	−	−			
3-134	192	−	−			
3-135	193	+	+			
3-136	194	+	−			
3-137	195	−	−			
3-138	196	+	+			
3-139	197	+	+			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 1 — Continued.

Laboratory Number.	Hen Number.	AGGLUTINATION TEST.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
3-140	198	+	+			
3-141	*198	−	−			
3-142	199	+	+			
3-143	200	+	−			
3-144	*200	+	+			
3-145	202	+	+			
3-146	203	−	−			
3-147	205	−	−			
3-148	206	−	−			
3-149	208	+	+			
3-150	209	+	+			
3-151	210	−	−			
3-152	213	−	−			
3-153	214	−	−			
3-154	218	+	+			
3-155	219	+	−			
3-156	220	+	+			
3-157	*220	+	+			
3-158	221	+	+			
3-159	223	−	−			
3-160	224	−	−			
3-161	231	−	−			
3-162	250	−	−			
3-163	277	+	+			
3-164	283	+	+			
3-165	306	+	+			
3-166	321	+	+			
3-167	326	+	+			
3-168	336	+	+			
3-169	346	+	+			
3-170	355	−	−			
3-171	359	−	−			
3-172	419	+	+			
3-173	436	+	+			
3-174	443	+	+			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 1 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
3-175	445					
3-176	453	+	+			
3-177	457	–	–			
3-178	459	–	–			
3-179	466	–	–			
3-180	481	+	+			
3-181	487	+	+			
3-182	488	–	–			
3-183	494	+	+			
3-184	498	+	–			
3-185	517	+	+			
3-186	537	+	+			
3-187	550	–	–			
3-188	570	+	+			
3-189	575	+	+			
3-190	594	+	+			
3-191	Male 6	–	–			
3-192	Male 19	–	–			
3-193	Male 55					
3-194	Male 57	–	–			
3-195	Male 112	–	–			
3-196	Male 113	–	–			
3-197	Male 139	–	–			
3-198	Male 166	–	–			
3-199	Male 201	–	–			
3-200	Male 235	–	–			
3-201	Male 289					
3-202	Male 295	+	+			
3-203	Male 499	–	–	203[1]	100	50.0

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[1] Of 203 samples drawn, 3 were received in condition not suitable for further work.

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2.

Laboratory Number.	Hen Number.	AGGLUTINATION TEST.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1–100.	Dilution 1–200.			
2– 1	13	–	–			
2– 2	16	+	–			
2– 3	19	–	–			
2– 4	45	–	–			
2– 5	49	–	–			
2– 6	67	–	–			
2– 7	119	–	–			
2– 8	122	–	–			
2– 9	129	–	–			
2– 10	*129	–	–			
2– 11	130	–	–			
2– 12	133	–	–			
2– 13	136	–	–			
2– 14	139	–	–			
2– 15	174	–	–			
2– 16	209	–	–			
2– 17	210	–	–			
2– 18	245	–	–			
2– 19	268	–	–			
2– 20	284	–	–			
2– 21	288	+	–			
2– 22	294	–	–			
2– 23	302	–	–			
2– 24	303	–	–			
2– 25	304	–	–			
2– 26	305	–	–			
2– 27	312	–	–			
2– 28	330	–	–			
2– 29	393	–	–			
2– 30	395	–	–			
2– 31	400	–	–			
2– 32	411	–	–			
2– 33	413	+	+			
2– 34	415	+	+			

Chart showing Results af Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2- 35	446	−	−			
2- 36	447	−	−			
2- 37	448	−	−			
2- 38	449	−	−			
2- 39	462	−	−			
2- 40	506	−	−			
2- 41	558	−	−			
2- 42	611	−	−			
2- 43	640	−	−			
2- 44	655	−	−			
2- 45	664	−	−			
2- 46	714	−	−			
2- 47	728	−	−			
2- 48	732	−	−			
2- 49	753	−	−			
2- 50	759	+	+			
2- 51	762	+	+			
2- 52	763	−	−			
2- 53	784	−	−			
2- 54	813	−	−			
2- 55	892	−	−			
2- 56	1015	−	−			
2- 57	1016	−	−			
2- 58	1043	−	−			
2- 59	1055	−	−			
2- 60	1068	+	−			
2- 61	1412	+	+			
2- 62	1444	−	−			
2- 63	2311	−	−			
2- 64	2324	−	−			
2- 65	2340	−	−			
2- 66	2344	+	+			
2- 67	2352	−	−			
2- 68	2379	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2- 69	2405	+	−			
2- 70	2427	−	−			
2- 71	2437	+	−			
2- 72	2443	−	−			
2- 73	2453	−	−			
2- 74	2454	−	−			
2- 75	2455	−	−			
2- 76	2469	−	−			
2- 77	2471	+	−			
2- 78	2478	−	−			
2- 79	2479	−	−			
2- 80	2481	−	−			
2- 81	2484	−	−			
2- 82	2485	−	−			
2- 83	2494	−	−			
2- 84	2522	−	−			
2- 85	2532	−	−			
2- 86	2540	−	−			
2- 87	2541	−	−			
2- 88	2547	−	−			
2- 89	2551	−	−			
2- 90	2552	−	−			
2- 91	2555	−	−			
2- 92	2558	−	−			
2- 93	2559	−	−			
2- 94	2560	+	−			
2- 95	2564	−	−			
2- 96	2565	−	−			
2- 97	2567	−	−			
2- 98	2591	−	−			
2- 99	2637	+	−			
2-100	2638	−	−			
2-101	2670	+	−			
2-102	2675	+	+			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-103	2683	–	–			
2-104	2691	–	–			
2-105	2693	–	–			
2-106	2701	–	–			
2-107	2703	–	–			
2-108	2742	–	–			
2-109	2746	–	–			
2-110	2787	–	–			
2-111	2790	–	–			
2-112	2794	–	–			
2-113	2834	–	–			
2-114	2839	–	–			
2-115	2840	–	–			
2-116	2841	–	–			
2-117	2855	–	–			
2-118	2858	–	–			
2-119	2859	–	–			
2-120	2861	–	–			
2-121	2863	–	–			
2-122	2878	+	–			
2-123	3006	+	–			
2-124	3116	+	–			
2-125	3030	–	–			
2-126	3080	–	–			
2-127	3081	–	–			
2-128	3083	–	–			
2-129	3088	–	–			
2-130	3131	–	–			
2-131	3151	–	–			
2-132	3163	–	–			
2-133	3172	–	–			
2-134	3177	–	–			
2-135	3179	–	–			
2-136	3180	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-137	3182	–	–			
2-138	3208	–	–			
2-139	3256	–	–			
2-140	3257	+	+			
2-141	3258	+	+			
2-142	3324	–	–			
2-143	3336	–	–			
2-144	3337	+	+			
2-145	3357	–	–			
2-146	3358	–	–			
2-147	3365	–	–			
2-148	3366	–	–			
2-149	3377	–	–			
2-150	3394	–	–			
2-151	3411	–	–			
2-152	3413	–	–			
2-153	3415	–	–			
2-154	3489	–	–			
2-155	3491	–	–			
2-156	3492	–	–			
2-157	3504	+	+			
2-158	3507	–	–			
2-159	3521	–	–			
2-160	3524	–	–			
2-161	3532	–	–			
2-162	3546	–	–			
2-163	3557	+	–			
2-164	3565	–	–			
2-165	3567	–	–			
2-166	3571	–	–			
2-167	3578	–	–			
2-168	3588	–	–			
2-169	3589	–	–			
2-170	3600	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-171	3601	–	–			
2-172	3625	–	–			
2-173	3627	–	–			
2-174	3634	–	–			
2-175	3639	–	–			
2-176	3640	–	–			
2-177	3659	–	–			
2-178	3693	–	–			
2-179	3694	–	–			
2-180	3719	–	–			
2-181	3919	+	+			
2-182	4002	+	+			
2-183	4007	–	–			
2-184	4012	–	–			
2-185	4017	–	–			
2-186	4018	–	–			
2-187	4021	–	–			
2-188	4022	–	–			
2-189	4024	–	–			
2-190	4027	–	–			
2-191	4030	–	–			
2-192	4039	–	–			
2-193	4041	–	–			
2-194	4042	–	–			
2-195	4043	–	–			
2-196	4045	–	–			
2-197	4046	–	–			
2-198	4054	–	–			
2-199	4055	–	–			
2-200	4058	–	–			
2-201	4068	–	–			
2-202	4070	–	–			
2-203	4071	–	–			
2-204	4072	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-205	4076	−	−			
2-206	4086	−	−			
2-207	4087	−	−			
2-208	4090	+	+			
2-209	4091	−	−			
2-210	4095	−	−			
2-211	4097	−	−			
2-212	4099	−	−			
2-213	4100	−	−			
2-214	4101	−	−			
2-215	4103	−	−			
2-216	4107	−	−			
2-217	4109	−	−			
2-218	4113	+	+			
2-219	4116	−	−			
2-220	4119	−	−			
2-221	4120	−	−			
2-222	4121	−	−			
2-223	4124	−	−			
2-224	4125	−	−			
2-225	4126	−	−			
2-226	4127	−	−			
2-227	4130	−	−			
2-228	4131	−	−			
2-229	4132	−	−			
2-230	4135	−	−			
2-231	4136	−	−			
2-232	4138	−	−			
2-233	4139	−	−			
2-234	4140	−	−			
2-235	4141	−	−			
2-236	4145	−	−			
2-237	4146	−	−			
2-238	4149	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-239	4151	–	–			
2-240	4155	–	–			
2-241	4156	–	–			
2-242	4173	–	–			
2-243	4178	–	–			
2-244	4181	–	–			
2-245	4182	–	–			
2-246	4183	–	–			
2-247	4184	–	–			
2-248	4186	+	+			
2-249	4251	–	–			
2-250	4252	–	–			
2-251	4254	–	–			
2-252	4255	–	–			
2-253	4256	–	–			
2-254	4257	–	–			
2-255	4259	–	–			
2-256	4261	–	–			
2-257	4262	–	–			
2-258	4263	–	–			
2-259	4266	–	–			
2-260	4267	–	–			
2-261	4268	–	–			
2-262	4269	–	–			
2-263	4270	–	–			
2-264	4272	–	–			
2-265	4273	–	–			
2-266	4274	–	–			
2-267	4275	–	–			
2-268	4621	+	+			
2-269	4666	–	–			
2-270	4667	–	–			
2-271	4694	–	–			
2-272	4695	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1–100.	Dilution 1–200.			
2–273	4724	–	–			
2–274	4753	–	–			
2–275	7256	–	–			
2–276	7257	–	–			
2–277	7258	–	–			
2–278	7259	–	–			
2–279	7261	–	–			
2–280	7262	–	–			
2–281	7263	–	–			
2–282	7264	–	–			
2–283	72600	–	–			
2–284	0407	+	+			
2–285	A0401T	–	–			
2–286	A0402T	–	–			
2–287	A0403T	–	–			
2–288	A0404T	–	–			
2–289	A0405T	–	–			
2–290	A0406T	–	–			
2–291	A0410T	–	–			
2–292	A0412T	–	–			
2–293	A0414T	–	–			
2–294	A0416T	–	–			
2–295	A0417T	–	–			
2–296	A0418T	–	–			
2–297	A0419T	–	–			
2–298	A0420T	–	–			
2–299	A0421T	–	–			
2–300	A0422T	+	–			
2–301	A0423T	–	–			
2–302	A254	–	–			
2–303	A255	–	–			
2–304	A258	–	–			
2–305	A269	–	–			
2–306	A279	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-307	A296	+	+			
2-308	A297	−	−			
2-309	A302	−	−			
2-310	A304	−	−			
2-311	A323	−	−			
2-312	A325	−	−			
2-313	A330	−	−			
2-314	A332	−	−			
2-315	A350	−	−			
2-316	A355	−	−			
2-317	A360	−	−			
2-318	A372	−	−			
2-319	A374	−	−			
2-320	A379	−	−			
2-321	A382	−	−			
2-322	A394	−	−			
2-323	C13	−	−			
2-324	C19	−	−			
2-325	C53	+	−			
2-326	C70970	−	−			
2-327	C70990	−	−			
2-328	C72510	−	−			
2-329	C72520	−	−			
2-330	C72530	−	−			
2-331	C72540	−	−			
2-332	C72550	−	−			
2-333	C72770	−	−			
2-334	C72780	−	−			
2-335	C72790	−	−			
2-336	C72800	−	−			
2-337	Conn311	−	−			
2-338	Conn314	−	−			
2-339	Conn320	−	−			
2-340	1R	+	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 2 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
2-341	2R	–	–			
2-342	3R	–	–			
2-343	4R	–	–			
2-344	5R	–	–			
2-345	6R	–	–			
2-346	7R	–	–			
2-347	8R	–	–			
2-348	9R	–	–			
2-349	10R	–	–			
2-350	11R	–	–			
2-351	12R	–	–			
2-352	13R	–	–			
2-353	14R	–	–			
2-354	15R	+	+			
2-355	16R	–	–			
2-356	21R	–	–			
2-357	17L	–	–			
2-358	18L	–	–			
2-359	19L	–	–			
2-360	20L	–	–			
2-361	4172	–	–			
2-362	4185	–	–			
2-363	4195	–	–			
2-364	4196	–	–			
2-365	4197	–	–			
2-366	4198	–	–			
2-367	4199	–	–	367	36	9.8

District 3.

8- 1	1	–	–			
8- 2	3	–	–			
8- 3	4	–	–			
8- 4	6	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 3 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
8- 5	7	–	–			
8- 6	8	–	–			
8- 7	11	–	–			
8- 8	13	–	–			
8- 9	15	–	–			
8-10	17	–	–			
8-11	18	–	–			
8-12	19	–	–			
8-13	21	–	–			
8-14	25	–	–			
8-15	27	–	–			
8-16	33	–	–			
8-17	35	–	–			
8-18	36	–	–			
8-19	37	–	–			
8-20	38	–	–			
8-21	39	–	–			
8-22	*39	–	–			
8-23	40	–	–			
8-24	42	–	–			
8-25	51	–	–			
8-26	52	–	–			
8-27	54	–	–			
8-28	87	–	–			
8-29	91	–	–			
8-30	96	–	–	30	0	0.0
9- 1	2	+	+			
9- 2	17Y	–	–			
9- 3	18	–	–			
9- 4	21	–	–			
9- 5	24	–	–			
9- 6	29	–	–			
9- 7	37	+	+			
9- 8	40	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 3 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
9- 9	44	−	−			
9-10	53Y	+	+			
9-11	61	−	−			
9-12	65	−	−			
9-13	66	−	−			
9-14	H70	−	−			
9-15	77	−	−			
9-16	80	−	−			
9-17	84	−	−			
9-18	86	+	+			
9-19	87	+	+			
9-20	92	−	−			
9-21	762	+	+			
9-22	3830	−	−			
9-23	5469U	+	+			
9-24	D4056	+	+			
9-25	D4078	+	+			
9-26	D4083	+	+			
9-27	B26	+	+			
9-28	B28	−	−			
9-29	B43	−	−			
9-30	B75	−	−			
9-31	B91	+	+			
9-32	P6	−	−			
9-33	P12	−	−			
9-34	P20	+	+			
9-35	P52	−	−			
9-36	P57	+	+			
9-37	P62	−	−			
9-38	P70	+	−			
9-39	P76	−	−			
9-40	P81	+	+			
9-41	P82	−	−			
9-42	P85	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 3 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
9–43	P96	–	–			
9–44	P99	+	+			
9–45	P784	–	–	45	17	37.7

District 5.

6– 1	052	–	–			
6– 2	053	–	–			
6– 3	054	–	–			
6– 4	055	–	–			
6– 5	056	+	+			
6– 6	057	+	+			
6– 7	058	+	+			
6– 8	060	+	+			
9– 9	061	–	–			
6– 10	062	–	–			
6– 11	063	–	–			
6– 12	064	–	–			
6– 13	065	–	–			
6– 14	066	–	–			
6– 15	067	+	+			
6– 16	068	+	+			
6– 17	1-021	–	–			
6– 18	1-027	–	–			
6– 19	1-032	+	–			
6– 20	1-033	–	–			
6– 21	1-034	–	–			
6– 22	1-035	–	–			
6– 23	1-036	+	+			
6– 24	1-037	–	–			
6– 25	1-041	–	–			
6– 26	1-045	+	+			
6– 27	1-059	+	+			
6– 28	1-68	+	+			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 5 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
6- 29	1-93	−	−			
6- 30	1-95	−	−			
6- 31	1-96	+	+			
6- 32	1-97	+	−			
6- 33	1-98	+	+			
6- 34	1-8W11	−	−			
6- 35	1-8W20	+	+			
6- 36	2-087	−	−			
6- 37	2-17	−	−			
6- 38	2-22	−	−			
6- 39	2-24	−	−			
6- 40	2-28	−	−			
6- 41	2-29	−	−			
6- 42	2-31	−	−			
6- 43	2-51	−	−			
6- 44	2-52	−	−			
6- 45	2-56	−	−			
6- 46	2-61	−	−			
6- 47	2-65	−	−			
6- 48	2-67	−	−			
6- 49	2-72	−	−			
6- 50	2-74	−	−			
6- 51	2-75	−	−			
6- 52	2-77	−	−			
6- 53	2-88	−	−			
6- 54	2-?	−	−			
6- 55	3-32	+	+			
6- 56	3-48	+	+			
6- 57	3-97	−	−			
6- 58	3-8W1	+	+			
6- 59	3-8W4	−	−			
6- 60	3-8W7	+	+			
6- 61	3-8W10	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 5 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
6- 62	3-8W23	+	+			
6- 63	4-2	−	−			
6- 64	4-4	−	−			
6- 65	4-7	−	−			
6- 66	4-9	−	−			
6- 67	4-10	−	−			
6- 68	4-11	−	−			
6- 69	4-13	−	−			
6- 70	4-21	−	−			
6- 71	4-30	−	−			
6- 72	4-33	−	−			
6- 73	4-35	−	−			
6- 74	4-42	−	−			
6- 75	4-47	−	−			
6- 76	4-50	−	−			
6- 77	4-66	−	−			
6- 78	4-73	−	−			
6- 79	4-84	−	−			
6- 80	4-85	−	−			
6- 81	4-86	−	−			
6- 82	4-94	−	−			
6- 83	5-050	−	−			
6- 84	5-83	−	−			
6- 85	5-805	−	−			
6- 86	5-1925	+	+			
6- 87	5-1956	+	+			
5- 88	5-2002	+	+			
6- 89	6-5	−	−			
6- 90	6-9	−	−			
6- 91	6-19	−	−			
6- 92	6-20	−	−			
6- 93	6-27	−	−			
6- 94	6-36	−	−			
6- 95	6-43	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 5 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test. Dilution 1–100.	Agglutination Test. Dilution 1–200.	Total Number in Flock.	Total Number infected.	Per Cent. infected.
6– 96	6–44	–	–			
6– 97	6–46	–	–			
6– 98	6–48	–	–			
6– 99	6–60	–	–			
6–100	B01	–	–			
6–101	B02	+	+			
6–102	B03	–	–			
6–103	B04	–	–			
6–104	B05	–	–			
6–105	B06	–	–			
6–106	B08	–	–			
6–107	B09	–	–			
6–108	B010	+	+			
6–109	B011	+	+			
6–110	B012	–	–			
6–111	B013	–	–			
6–112	*B013	+	+			
6–113	B014	–	–			
6–114	B015	+	–			
6–115	B016	–	–			
6–116	B017	+	+			
6–117	B018	–	–			
6–118	B019	–	–			
6–119	B020	–	–			
6–120	B022	–	–			
6–121	B023	–	–			
6–122	B024	+	+			
6–123	B025	+	+			
6–124	B028	–	–			
6–125	B029	–	–			
6–126	B047	+	+			
6–127	B9	–	–			
6–128	B59	+	+			
6–129	B8W5	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 5 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
6-130	B8W15	–	–			
6-131	B8W16	–	–			
6-132	B8W17	–	–			
6-133	Male X044	–	–			
6-134	Male X083	–	–			
6-135	Male X090	–	–			
6-135	Male X5	–	–			
6-137	Male X7	–	–			
6-138	Male X13	–	–			
6-139	Male X14	–	–			
6-140	Male X17	–	–			
6-141	Male XB22	–	–			
6-142	Male X23	–	–			
6-143	Male X40	–	–			
6-144	Male XB49	–	–			
6-145	Male XB90	–	–			
6-146	Male X95	–	–			
6-147	Male X100	–	–			
6-148	Male X8W8	–	–			
6-149	Male X8W19	–	–	149	33	22.1

District 6.

7- 1	1A-5	+	+			
7- 2	1A-16	+	+			
7- 3	1A-48	–	–			
7- 4	1A-800	+	+			
7- 5	1B-11	–	–			
7- 6	1B-23	+	+			
7- 7	1B-46	–	–			
7- 8	1B-120	+	+			
7- 9	1B-124	+	+			
7-10	1B-A299	+	+			
7-11	1B-*0999G	+	+			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 6 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
7-12	1C-10	–	–			
7-13	1C-763	–	–			
7-14	3-4	–	–			
7-15	3-10	–	–			
7-16	3-27	–	–			
7-17	3-39	–	–			
7-18	3-61	–	–			
7-19	3-90	+	–			
7-20	3-94	–	–			
7-21	3-97	–	–			
7-22	4-1	+	+			
7-23	4-14	–	–			
7-24	4-18	–	–			
7-25	4-19	+	+			
7-26	4-45	–	–			
7-27	4-46	+	+			
7-28	4-795	+	+			
7-29	5-3	–	–			
7-30	5-6	–	–			
7-31	5-12	+	–			
7-32	5-21	–	–			
7-33	5-22	–	–			
7-34	5-36	–	–			
7-35	5-98	+	+			
7-36	5-100	–	–			
7-37	6-2	+	–			
7-38	6-3	–	–			
7-39	6-12	–	–			
7-40	6-30	+	+			
7-41	6-32	–	–			
7-42	6-77	–	–			
7-43	6-268	+	+			
7-44	6-A276	+	+			
7-45	8-4	+	+			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 6 — Concluded.

Laboratory Number.	Hen Number.	AGGLUTINATION TEST.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
7-46	8-34	−	−			
7-47	8-807	+	+			
7-48	8-810	+	+			
7-49	9-87	−	−			
7-50	14-5	−	−			
7-51	14-12	−	−			
7-52	Male 11	−	−			
7-53	Male 34	−	−			
7-54	Male 47	−	−			
7-55	Male 85	−	−			
7-56	Male 746	−	−			
7-57	Male 780	−	−			
7-58	Male 781	+	+			
7-59	Male 836	−	−	59	23	38.9

District 7.

5- 1	1	−	−			
5- 2	2	−	−			
5- 3	3	−	−			
5- 4	4	+	−			
5- 5	5	−	−			
5- 6	6	−	−			
5- 7	7	−	−			
5- 8	8	−	−			
5- 9	9	−	−			
5-10	10	−	−			
5-11	11	−	−			
5-12	12	−	−			
5-13	13	−	−			
5-14	14	−	−			
5-15	15	−	−			
5-16	16	−	−			
5-17	17	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 7 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
5-18	18	+	−			
5-19	19	−	−			
5-20	20	−	−			
5-21	21	−	−			
5-22	22	+	−			
5-23	23	−	−			
5-24	24	−	−			
5-25	25	−	−			
5-26	26	−	−			
5-27	27	−	−			
5-28	28	−	−			
5-29	29	−	−			
5-30	30	−	−			
5-31	31	−	−			
5-32	32	−	−			
5-33	33	-	-			
5-34	34	−	−			
5-35	35	−	−			
5-36	36	−	−			
5-37	37	−	−			
5-38	38	−	−			
5-39	39	−	−			
5-40	40	−	−			
5-41	41	−	−			
5-42	42	−	−			
5-43	Male 1	−	−			
5-44	Male 2	−	−			
5-45	Male 7	−	−	45	3	6.6

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4- 1	139	–	–			
4- 2	140	+	–			
4- 3	141	–	–			
4- 4	142	–	–			
4- 5	143	–	–			
4- 6	145	–	–			
4- 7	146	–	–			
4- 8	147	+	–			
4- 9	148	–	–			
4- 10	150	–	–			
4- 11	151	–	–			
4- 12	152	–	–			
4- 13	154	–	–			
4- 14	155	–	–			
4- 15	157	–	–			
4- 16	158	–	–			
4- 17	159	–	–			
4- 18	160	–	–			
4- 19	161	–	–			
4- 20	162	–	–			
4- 21	163	–	–			
4- 22	164	–	–			
4- 23	165	+	–			
4- 24	166	–	–			
4- 25	167	+	+			
4- 26	168	+	+			
4- 27	169	–	–			
4- 28	171	–	–			
4- 29	172	+	+			
4- 30	173	+	–			
4- 31	174	–	–			
4- 32	175	–	–			
4- 33	176	–	–			
4- 34	177	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4- 35	178	–	–			
4- 36	179	–	–			
4- 37	180	–	–			
4- 38	181	–	–			
4- 39	182	+	+			
4- 40	183	–	–			
4- 41	184	–	–			
4- 42	185	–	–			
4- 43	187	+	+			
4- 44	188	–	–			
4- 45	189	–	–			
4- 46	190	–	–			
4- 47	191	–	–			
4- 48	193	+	+			
4- 49	194	–	–			
4- 50	195	–	–			
4- 51	196	–	–			
4- 52	198	+	+			
4- 53	199	+	+			
4- 54	201	–	–			
4- 55	202	–	–			
4- 56	203	+	+			
4- 57	205	–	–			
4- 58	206	–	–			
4- 59	208	–	–			
4- 60	209	–	–			
4- 61	210	–	–			
4- 62	211	–	–			
4- 63	212	+	+			
4- 64	213	+	+			
4- 65	214	–	–			
4- 66	216	–	–			
4- 67	217	–	–			
4- 68	218	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4- 69	220	+	+			
4- 70	221	−	−			
4- 71	222	+	+			
4- 72	223	−	−			
4- 73	224	−	−			
4- 74	226	−	−			
4- 75	227	−	−			
4- 76	230	−	−			
4- 77	231	−	−			
4- 78	232	−	−			
4- 79	233	−	−			
4- 80	234	−	−			
4- 81	235	−	−			
4- 82	236	−	−			
4- 83	237	−	−			
4- 84	240	−	−			
4- 85	241	−	−			
4- 86	242	−	−			
4- 87	243	−	−			
4- 88	244	−	−			
4- 89	245	−	−			
4- 90	246	−	−			
4- 91	247	−	−			
4- 92	249	+	+			
4- 93	250	−	−			
4- 94	251	−	−			
4- 95	252	−	−			
4- 96	253	−	−			
4- 97	254	−	−			
4- 98	255	−	−			
4- 99	256	+	+			
4-100	257	−	−			
4-101	259	−	−			
4-102	260	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4-103	262	–	–			
4-104	263	–	–			
4-105	264	–	–			
4-106	265	–	–			
4-107	266	–	–			
4-108	268	+	+			
4-109	269	–	–			
4-110	270	–	–			
4-111	271	–	–			
4-112	272	–	–			
4-113	274	–	–			
4-114	275	–	–			
4-115	276	–	–			
4-116	278	+	+			
4-117	279	–	–			
4-118	281	–	–			
4-119	282	+	+			
4-120	284	–	–			
4-121	285	+	+			
4-122	286	+	+			
4-123	287	–	–			
4-124	288	–	–			
4-125	289	–	–			
4-126	290	–	–			
4-127	291	–	–			
4-128	293	–	–			
4-129	294	–	–			
4-130	295	–	–			
4-131	296	–	–			
4-132	297	–	–			
4-133	298	+	+			
4-134	299	–	–			
4-135	300	+	–			
4-136	301	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1–100.	Dilution 1–200.			
4–137	302	−	−			
4–138	303	−	−			
4–139	304	+	+			
4–140	305	−	−			
4–141	306	−	−			
4–142	307	−	−			
4–143	308	+	+			
4–144	310	+	+			
4–145	311	−	−			
4–146	312	−	−			
4–147	313	−	−			
4–148	314	−	−			
4–149	315	+	+			
4–150	316	−	−			
4–151	317	−	−			
4–152	318	−	−			
4–153	319	−	−			
4–154	320	−	−			
4–155	321	+	+			
4–156	323	+	+			
4–157	326	−	−			
4–158	327	−	−			
4–159	328	−	−			
4–160	329	−	−			
4–161	330	−	−			
4–162	331	+	+			
4–163	332	+	+			
4–164	335	−	−			
4–165	336	−	−			
4–166	337	+	−			
4–167	338	−	−			
4–168	339	−	−			
4–169	340	−	−			
4–170	341	−	−			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1–100.	Dilution 1–200.			
4–171	342	–	–			
4–172	343	–	–			
4–173	344	–	–			
4–174	345	–	–			
4–175	346	–	–			
4–176	347	–	–			
4–177	348	–	–			
4–178	349	–	–			
4–179	350	–	–			
4–180	352	–	–			
4–181	354	–	–			
4–182	355	–	–			
4–183	356	–	–			
4–184	358	–	–			
4–185	359	–	–			
4–186	360	–	–			
4–187	361	–	–			
4–188	362	–	–			
4–189	363	+	–			
4–190	364	+	+			
4–191	365	–	–			
4–192	366	–	–			
4–193	367	–	–			
4–194	368	–	–			
4–195	369	+	+			
4–196	370	–	–			
4–197	371	+	+			
4–198	372	–	–			
4–199	374	–	–			
4–200	375	–	–			
4–201	376	–	–			
4–202	378	+	+			
4–203	379	–	–			
4–204	380	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	AGGLUTINATION TEST.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4-205	381	–	–			
4-206	382	–	–			
4-207	384	–	–			
4-208	385	–	–			
4-209	386	–	–			
4-210	387	–	–			
4-211	392	–	–			
4-212	393	+	–			
4-213	394	+	+			
4-214	396	–	–			
4-215	399	+	+			
4-216	Y3	–	–			
4-217	Y11	–	–			
4-218	Y12	–	–			
4-219	Y14	–	–			
4-220	Y16	–	–			
4-221	Y23	–	–			
4-222	Y26	+	–			
4-223	Y33	–	–			
4-224	Y38	–	–			
4-225	Y39	–	–			
4-226	Y42	–	–			
4-227	Y44	–	–			
4-228	Y45	–	–			
4-229	Y46	–	–			
4-230	Y47	–	–			
4-231	Y48	–	–			
4-232	Y49	–	–			
4-233	Y56	–	–			
4-234	Y57	–	–			
4-235	Y58	–	–			
4-236	Y60	–	–			
4-237	Y61	–	–			
4-238	Y64	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4-239	Y65	–	–			
4-240	Y66	–	–			
4-241	Y67	–	–			
4-242	Y70	–	–			
4-243	Y73	–	–			
4-244	Y77	–	–			
4-245	Y80	–	–			
4-246	Y81	–	–			
4-247	Y82	–	–			
4-248	Y83	–	–			
4-249	Y84	–	–			
4-250	Y85	–	–			
4-251	Y89	+	–			
4-252	Y92	–	–			
4-253	Y93	–	–			
4-254	Y94	+	–			
4-255	Y95	–	–			
4-256	Y96	–	–			
4-257	Y97	–	–			
4-258	Y98	–	–			
4-259	Y99	–	–			
4-260	Y100	–	–			
4-261	Y101	–	–			
4-262	Y104	–	–			
4-263	Y106	–	–			
4-264	Y110	–	–			
4-265	Y111	–	–			
4-266	Y112	–	–			
4-267	Y115	–	–			
4-268	Y120	–	–			
4-269	Y121	+	+			
4-270	Y122	+	+			
4-271	Y123	–	–			
4-272	Y124	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 8 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
4-273	Y126	–	–			
4-274	Y127	–	–			
4-275	Y128	–	–			
4-276	Y129	+	–			
4-277	Y130	+	+			
4-278	Y131	–	–			
4-279	Y133	–	–			
4-280	Y135	–	–			
4-281	Y136	–	–			
4-282	Y137	–	–			
4-283	Y138	–	–			
4-284	Y397	–	–	284	50	17.6

District 10.

Laboratory Number.	Hen Number.	Dilution 1-100.	Dilution 1-200.	Total Number in Flock.	Total Number infected.	Per Cent. infected.
1- 1	101	–	–			
1- 2	103	–	–			
1- 3	104	–	–			
1- 4	215	–	–			
1- 5	551	–	–			
1- 6	552	–	–			
1- 7	553	–	–			
1- 8	554	–	–			
1- 9	556	–	–			
1-10	558	–	–			
1-11	560	–	–			
1-12	561	–	–			
1-13	562	–	–			
1-14	563	–	–			
1-15	564	–	–			
1-16	565	+	+			
1-17	566	–	–			
1-18	567	–	–			
1-19	569	–	–			

Chart showing Results of Agglutination Tests, etc. — Continued.

District 10 — Continued.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
1-20	570	–	–			
1-21	573	–	–			
1-22	574	–	–			
1-23	577	–	–			
1-24	581	–	–			
1-25	583	–	–			
1-26	584	–	–			
1-27	588	–	–			
1-28	589	–	–			
1-29	591	–	–			
1-30	594	+	+			
1-31	598	–	–			
1-32	599	–	–			
1-33	601	–	–			
1-34	604	–	–			
1-35	606	–	–			
1-36	611	+	+			
1-37	613	+	+			
1-38	615	+	+			
1-39	617	–	–			
1-40	620	–	–			
1-41	621	–	–			
1-42	626	+	–			
1-43	631	–	–			
1-44	634	–	–			
1-45	637	–	–			
1-46	638	–	–			
1-47	644	–	–			
1-48	646	–	–			
1-49	657	–	–			
1-50	658	–	–			
1-51	660	–	–			
1-52	661	–	–			
1-53	665	–	–			

Chart showing Results of Agglutination Tests, etc. — Concluded.

District 10 — Concluded.

Laboratory Number.	Hen Number.	Agglutination Test.		Total Number in Flock.	Total Number infected.	Per Cent. infected.
		Dilution 1-100.	Dilution 1-200.			
1-54	667	–	–			
1-55	673	–	–			
1-56	674	–	–			
1-57	675	–	–			
1-58	676	–	–			
1-59	679	–	–			
1-60	680	–	–			
1-61	682	–	–			
1-62	683	–	–			
1-63	686	–	–			
1-64	687	–	–			
1-65	688	+	+			
1-66	690	–	–			
1-67	693	–	–			
1-68	695	–	–			
1-69	696	–	–			
1-70	697	–	–			
1-71	698	–	–			
1-72	700	–	–	72	7	9.7

DISTRIBUTION OF INFECTION AND TYPES OF STOCK INFECTED.

A study of the map and chart indicates that the infection is distributed throughout Massachusetts. It should be borne in mind, however, that this represents the work of but a short time on representative breeding flocks. A further study conducted along the same lines would undoubtedly result in furnishing data which would indicate that there exists throughout the State a general infection.

We have realized that there are several types of poultry work conducted in Massachusetts, *i.e.*, the management of poultry plants along lines best suited to the rearing of utility and fancy stock. In the data we are reporting are included the results from tests made on both types. Many poultrymen will say that they have bought their stock from the best that can be had, but this is no protection against infection. In way of illustration we might say that it has been the good fortune of the Department in the spring of 1914 and 1915 to be associated with some of the most practical and most enthusiastic poultry raisers in the State of Massachusetts in both lines. The results obtained indicate that infection is found in all types of breeding birds, — utility, fancy, birds raised in the State, birds brought into the State from other States, — and we have found it in stock which has been sent in from Europe.

Results of Application of these Methods for preventing and eradicating Bacillary White Diarrhea of Young Chicks.

After studying the charts it can be seen that in all districts of Massachusetts the organism has been found in young chicks, and also laying hens have been tested and found to be infected. For example, in District 1 a representative flock contained 50 per cent. of positive reactors, which would indicate that throughout this whole district the infection was general. In District 5, representative flocks showed that 22.1 per cent. of breeding birds were infected. From this we are led to believe that there is only a moderate degree of infection, but examination of dead chicks from this area of the State indicates heavy infection. In District 8, 17 per cent. of the breeding birds were infected in the representative flock chosen. From our work on chick examinations we are led to believe that this is indicative of the conditions in this locality. These results need no comment. They at least show that bacillary white diarrhea is widely distributed. They show, also, that being so generally scattered over the various areas of the State poultrymen should be made aware of its prevalence and willing to co-operate in every way to stamp it out.

It can be easily seen that in order to do this eggs used for hatching must come from sound, uninfected stock. This really is the only basis for improvement. The infected individual must be sought and eliminated from the breeding flock.

At the present time poultry raisers may feel that their labors are hopeless if white diarrhea should make its appearance in their young chicks. It is not the object of this paper to discourage present and prospective poultry raisers, but, with our methods of study, detection and control of this disease, to encourage greater effort in the industry. By thorough co-operation of poultrymen and laboratory workers a great improvement in raising young chicks must follow.

This infection is readily transmitted through eggs, day-old chicks and mature stock. Therefore, to insure against the infection poultrymen should buy only from stock known to be free from the infection. If all breeders would have their birds tested, and infected birds eliminated, their customers would be insured against buying infected stock. In other words, all stock should bear a stamp indicating tested and found negative.

Wherever the blood test has been made and the positive reactors eliminated a marked improvement has resulted in the young chicks hatched thereafter. Every poultryman co-operating with the Department thus for the improvement of his flock conditions by these methods has been convinced that conditions have improved. All are unanimous in placing their stamp of approval upon the work thus far conducted, and all hope the work in connection with the problem of eradication may be carried through to a successful finish.

We believe that the results both of our scientific work and of its practical application may be confidently depended upon and that examination will convince even the most skeptical. Poultrymen who have suffered great losses will be unanimous in supporting the views of workers in this Department; *i.e.*, that it is possible to rid Massachusetts for the most part of this disease, and that a campaign should be organized against bacillary white diarrhea infection.

The problem of eradicating *Bacterium pullorum* infection involves organization, clerical detail and a constant observation of the laws governing the study and progress of disease. It is a problem in practical pathology, and can be solved only by the pathologist and poultryman co-operating. The methods of the laboratory play an important part in the campaign. Therefore, intelligent, efficient and conscientious co-operation of all concerned is essential for success.

To efficiently handle the situation the work of the campaign must be centered in a strictly scientific atmosphere, since it requires pathological organization, efficient laboratory analyses and record keeping based on such knowledge. Therefore, if funds are provided, the Department of Veterinary Science with its laboratory equipment already established would be in a position to continue the work to help eliminate domestic fowls in the State of Massachusetts carrying *Bacterium pullorum* infection, which has been the cause of great mortality of young chicks.

DEPARTMENT OF CHEMISTRY.

PART I.

SUBSTITUTES FOR MILK IN THE REARING OF DAIRY CALVES.

BY J. B. LINDSEY.

INTRODUCTION.

With plenty of whole or skim milk available the rearing of dairy calves is a comparatively simple matter, providing one pays attention to such important details as clean pails, clean stalls, clean bedding and uses care in feeding. In such a State as Massachusetts, however, the price of whole milk renders its economical use in any quantity as a food for calves prohibitive, while skim milk is to be had only in quite limited amounts except in the immediate vicinity of the comparatively few creameries located west of the Connecticut River.

This lack of milk renders it very necessary that some substitute be provided if the dairyman is to raise his heifer calves in a satisfactory way. It is well known that the stomach of the calf is very sensitive during the first few months of its life, and it is doubtful if any substitute can be found or compounded which will completely take the place of milk. Numerous substitutes in the form of calf meals have been suggested, among which may be mentioned Liebig's Calf Soup,[1] Hansen's Potato Meal and Barley Malt,[1] and Hayward's Calf Meal.[2] Several proprietary mixtures are also to be noted, such as Lactina Suisse,[3] made in Switzerland; Bibby's Cream Equivalent, made in England; Blatchford's, Schumacher's and other calf meals, made in this country.

RESULTS OF EXPERIMENTS MADE AT THIS STATION.[4]

In the experiments reported, whole milk has been charged at 5 cents a quart, skim milk at .65 cent a quart, ordinary grain mixtures at 1.6 cents a pound, hay at $10 a ton,[5] and the calf meals at market price or actual cost of preparation.

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[1] Kellner's Ernährung d. Landw. Nutzthier., sixth ed., p. 283.

[2] Penn. Exp. Sta. Bul. 60.

[3] Cornell Exp. Sta. Bul. 269.

[4] Including citations from other experimenters.

[5] Assumed to be the cost of production.

I. Calves fed Whole Milk, Skim Milk and Ordinary Grains.

The station began to rear its own dairy calves for the purpose of replenishing the station herd as early as 1903. The method at that time consisted in feeding whole milk for the first week or ten days, then gradually substituting skim milk, until at the end of a month or six weeks the whole milk was entirely removed. When the calf was a month or six weeks of age a little flour wheat middlings was stirred into the milk, and a dry grain mixture was also put before the animals. This mixture usually consisted of equal parts, by weight, of wheat bran, flour middlings and corn meal. As the calves grew, and took increased amounts of dry grain, the addition of middlings to the milk was omitted. The skim-milk diet was usually continued until the animals were from six to seven or eight months of age, the supply of skim milk at the time being liberal.

The calves were usually dropped in the autumn and went to pasture the next spring.

The following record shows the amounts of the several feeds consumed, the total food cost, the cost of food for each pound of gain, and the total gain in weight: —

Results.

Calf.	Whole Milk (Pounds).	Skim Milk (Pounds).	Grain (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Maud,	164	4,974	301	986	$28 18	7.7	365	1.30	281
Susie,	143	4,326	249	505	22 79	6.9	333	1.40	237
Betty,	160	3,796	230	858	23 05	7.0	328	1.40	237
Mibbs,	264	5,228	301	1,059	31 96	8.6	370	1.32	280
Lena,	200	2,625	247	420	18 52	6.5	287	1.43	200
Red III.,	169	4,400	132	263	20 52	–	–	–[1]	197
Betty II.,	138	3,079	60	198	14 35	6.1	235	1.37	171
Fancy II.,	112	4,581	137	390	20 46	8.7	235	.91	258
Fancy III.,	180	3,765	238	545	23 66	9.5	250	.94	266
Amy W.,	110	3,793	114	312	17 29	8.6	200	.92	218
Average,	164	4,145	201	553	$22 08	7.7	289	1.22	235

[1] Not weighed at end of trial.

The above tabulation shows that the 10 calves, when fed on a combination of whole and skim milk, hay and ordinary grains for an average of 7.8 months (235 days) after birth, made an average daily gain of 1.22 pounds at a cost of $22.08 a head.

It is understood that such a liberal feeding with skim milk could not be followed excepting in those localities where skim milk is in liberal supply. Thus Fraser (Bulletin No. 164, Illinois Station) states that in the interest of economy all milk may be removed after eight weeks, and the animals placed upon a diet of mixed grain, clover and alfalfa hay. His experiments averaged 150 pounds whole milk and 450 pounds skim milk for each calf. He admits, however, that "when it is possible, more milk than herein recommended should be fed, as it is always best to keep the calf in a good growing condition from its birth to maturity. Calves thus fed were always healthy, and while they were rather thin, from the time they were eight to twelve or fifteen weeks old, they grew into good condition later, and made fine healthy heifers."

Morse[1] in 1898 fed young calves whole milk, skim milk and flaxseed jelly, the latter being used as a supplement to skim milk in replacing the milk fat. The average daily gain of 8 calves for five months was 1.37 pounds, and the total cost for each calf was $9.57. Whole milk was valued at $1, skim milk at 20 cents, and flaxseed meal at $3.25 a hundred pounds, much less than at present. Morse states that "flaxseed meal cannot be used with economy except in the earliest stages of growth, — the first two or three months, — and whole milk should be discontinued as soon as possible."

Wing [2] fed 12 calves until five months of age on skim milk, hay and grain, and found that they made an average gain of 1.5 pounds daily at a cost of about 5 cents a pound. He figured his skim milk at 15 cents a hundred, hay at $10 a ton and grain at about $30 a ton. He further concluded that the food cost of rearing a calf to five months of age is from $12 to $15. The fact that the calves fed under his supervision made a somewhat larger daily gain than ours at a less daily cost is due partly to the less price charged for the skim milk and to the shorter period (five instead of eight months). The older the animal the greater the cost of a pound of growth.

II. CALVES FED HAYWARD'S CALF MEAL.

This meal was compounded as follows: —

	Pounds.
Finely ground wheat or cheap flour,	30
Cocoanut meal,	25
Nutrium,	20
Linseed meal,	10
Blood flour,	2

Present cost a pound, 4.6 cents.

Hayward employed whole wheat ground by the local miller. St. Louis flour can also be used. Cocoanut meal [3] contains some 21 per cent. protein and 9 per cent. fat. Nutrium[1] is evaporated skim milk ground to a powder. Blood flour is prepared especially by Swift & Co. and Armour & Co., and costs about 3 cents a pound at Chicago.

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[1] Bul. 58, N. H. Exp. Sta.

[2] Bul. 269, Cornell Exp. Sta. (1909).

[3] Sold by the Oil Seeds Co., 35 South William Street, New York.

Method of Feeding. — The finely ground calf meal was stirred into very hot water at the rate of 1 pound of meal to 8 pounds of water. The gruel was fed when milk-warm. Hayward used a calf feeder, but in our case the animals were taught to drink the gruel. Two thrifty grade Jersey calves were fed whole milk for about nine days, then skim milk and calf-meal gruel gradually substituted, until at the end of three weeks the whole milk was entirely removed. At the end of five weeks the calves were receiving only the calf-meal gruel. Calf I. was kept on the gruel 143 days and Calf II. 101 days. Calf II. was not as robust as Calf I., and suffered a severe attack of indigestion during the trial, which rendered it necessary to take away a considerable portion of the meal and to substitute skim milk until the end of the experiment. While the calves did not have as sleek an appearance as if raised on a whole milk diet, they were in thrifty growing condition, and at the end of the trial appeared quite vigorous.

Results.

CALF.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Total Food Cost.	Cost of Food per Pound Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Calf I.,	202	130	374	$22 24	9.3	240	1.35	178
Calf II.,	152	352	306	18 64	9.8	190	1.10	169
Hayward's average with 12 calves,	121	–	186	11 34	9.6	118	1.18	102

The table shows that Calf I. made an average daily gain of 1.35 pounds, and Calf II., 1.10 pounds, which was satisfactory. The animals were nearly six months old when the trial was ended, Calf I. weighing 310 pounds and Calf II., 260 pounds. The total food cost and the cost of food per pound of live weight gained was rather more than desired. The chief objection to this calf meal is its cost, due to the use of the evaporated skim milk.

The table also includes the average results secured by Hayward with 12 calves from the first few days after they were dropped until the end of the experiment, which averaged 102 days. The cost of the milk and calf meal has been figured by us at 5 cents a quart and 4.6 cents a pound respectively. The 12 calves varied from 53 to 100 pounds at the beginning, and from 127 to 254 pounds in weight at the close, of the trial. The average daily gain and food cost per pound of gain do not vary greatly from our results. Hayward comments upon his results as follows: —

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[1] Sold by the National Nutrient Co., Jersey City, N. J. Other skim-milk powders are made by Merrill Soule Co., Syracuse, N.Y., and cost 12 or more cents a pound. Its cost renders its use in any large amount hardly economical.

> While calves made but slight gains when first put upon the calf meal, later they made as rapid gain as two which were fed a ration of skim milk to which some grain was added. Those that were fed the calf-meal ration were so nearly like the skim-milk calves in condition that it was impossible to tell from appearances which were and which were not being fed the calf meal. . . .
>
> Those that have been raised upon the calf meal have not been troubled with scours to any extent, and in this respect no difference could be seen between the calf-meal and the skim-milk calves. . . .
>
> Some calves appeared to be much more vigorous and thrifty than others, would take more kindly to the calf meal and do better than their less hardy neighbors.

III. Calves fed Schumacher's Calf Meal.

This meal, according to the manufacturers, is made from the residues in the preparation of puffed grains, wheat and oat meals, together with flaxseed meal, cottonseed meal and dried casein. It costs substantially 3.2 cents per pound at retail. It contains 15 to 17 per cent. protein, not much over 1.5 per cent. fiber, some 7 per cent. fat, 2 per cent. ash and about 60 per cent. of starchy matter.

Method of Feeding. — This meal was fed to two grade Holstein calves and one grade Jersey calf. Instead of following the directions outlined by the manufacturers, there was added to each 4 ounces of the meal a little cold water, and the material stirred to a paste. Then very hot water was added, allowing substantially 1 quart of water to each 4 ounces of meal, the mixture thoroughly stirred, allowed to cool and fed milk-warm. The general method of feeding these three calves consisted in giving whole milk for the first week, then gradually substituting skim milk and the calf-meal gruel. The whole milk was entirely replaced at the end of two weeks and the skim-milk and calf-meal gruels substituted. In case of these three calves 5 quarts of skim milk were fed daily and continuously as a basal food, together with 4 quarts of the calf-meal gruel. In addition, after some six weeks, dry calf meal and rowen were placed before the calves, and when some three to four months old the calves were eating 1 pound of the dry meal daily, at which time the calf-meal gruel and the skim milk were gradually removed.

Results.

Calf.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
No. II., ...	–	1,120	207	266	$11 31	8.3	135	.90	153
Samantha II., . . .	58	1,377	155	167	11 55	7.9	147	1.10	134
Daisy II., ...	46	1,600	213	257	13 96	8.5	165	1.02	162

The calves were in good condition at the end of the experiment and had made a reasonably fair gain in weight. They probably would have done well if the amount of skim milk fed daily had been reduced from 5 to 4 quarts, and the calf-meal gruel correspondingly increased.

Wing,[1] at the Cornell Station, reports the results of two experiments with feeding Schumacher's Calf Meal. The directions for feeding the calf meal as put out by the company were followed as accurately as circumstances would permit.

Wing's Results (Average per Calf).

NUMBER OF CALVES.	Total Food Cost.[2]	Cost of Food per Pound of Gain (Cents).	Total Average Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
6, ...	$12 14	8.1	150.1	1.25	120
4, ...	14 69	9.0	163.0	1.10	150

Wing remarks that "Schumacher's Calf Meal seems to be the best commercial substitute, in the nature of grain, for skimmed milk on the market at the present time (1909). It does not appear to be a complete substitute for skimmed milk, yet the gains from the use of this meal are good, and the cost of a pound of gain is fairly low."

IV. CALVES FED BLATCHFORD'S CALF MEAL.

We have not sufficient data to warrant any positive expression of opinion, it being fed to one calf only, — a vigorous grade Holstein. It did not seem advisable to feed the meal exclusively for the first three months of the calf's life, hence 4 quarts of skim milk were fed daily, and, in addition, what meal the calf would take, made into a gruel with hot water, and the mixture fed lukewarm. After it had reached the age of three months the milk was removed and the calf meal was given as the only food for six weeks, during which time it gained an average of 1.15 pounds daily, and did not suffer any digestive disturbances. This calf has made an excellent cow, and is known as Samantha. It was noted that the calf at first objected to the odor or taste of the meal, although no serious difficulty was encountered in inducing the animal to take it. At the present time its cost is about 3½ cents a pound, and it is composed, according to the manufacturers, of locust bean meal, wheat flour, flaxseed and linseed meals, cocoanut meal, ground beans and peas, cocoa shells, recleaned cottonseed meal, fenugreek and salt.

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[1] Already cited.

[2] Whole milk was charged at $1.65 and skim milk at 15 cents a hundred; hay at $10 and grain mixture at $29.55 a ton; the calf meal at $3.50 a hundred.

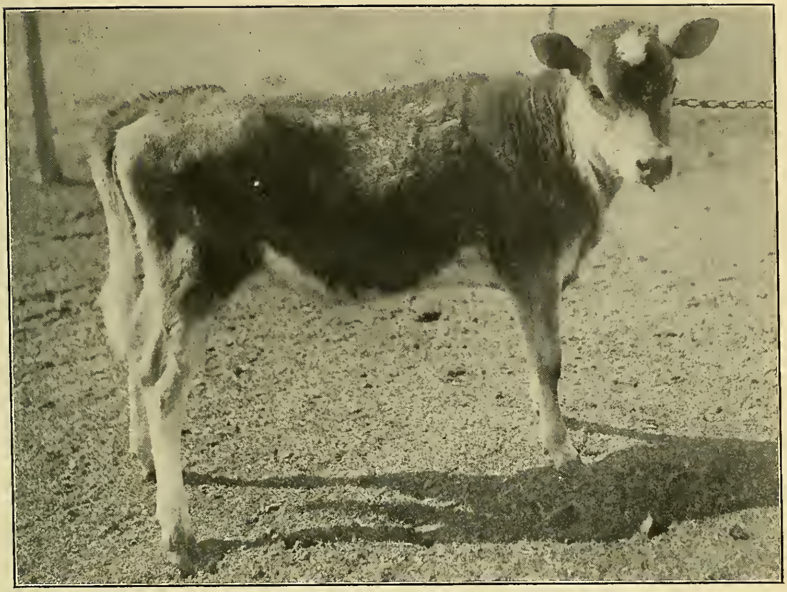

FIG. 1.—Daisy II. Schumacher's calf meal.

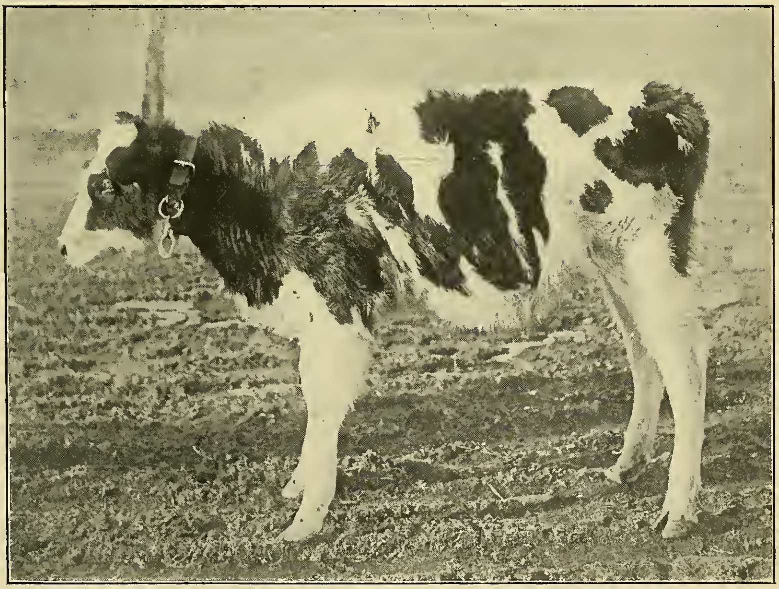

FIG. 2.—Samantha II. Schumacher's calf meal.

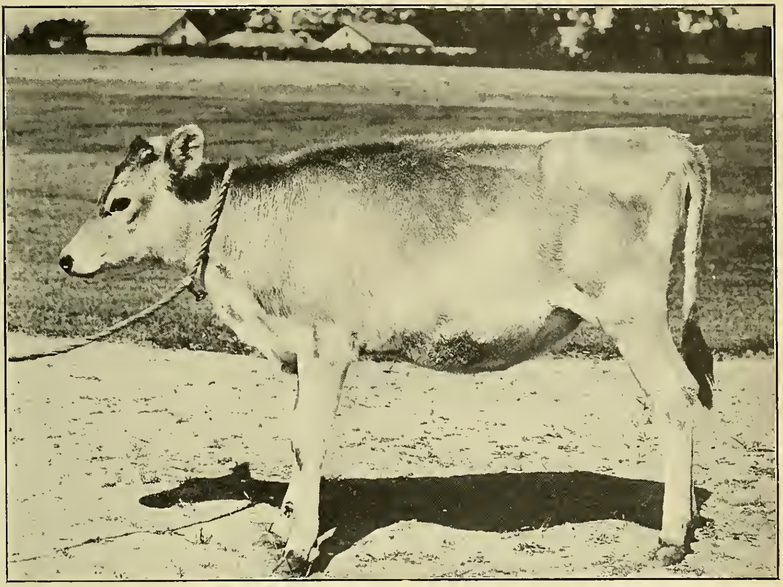

Fig. 3. — Cecile II. Bibby's cream equivalent.

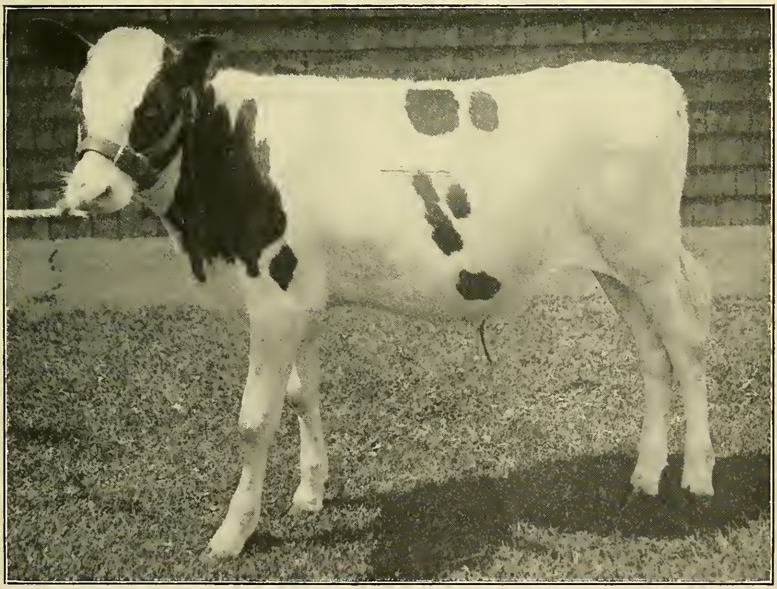

Fig. 4. — Holstein steer. Bibby's cream equivalent.

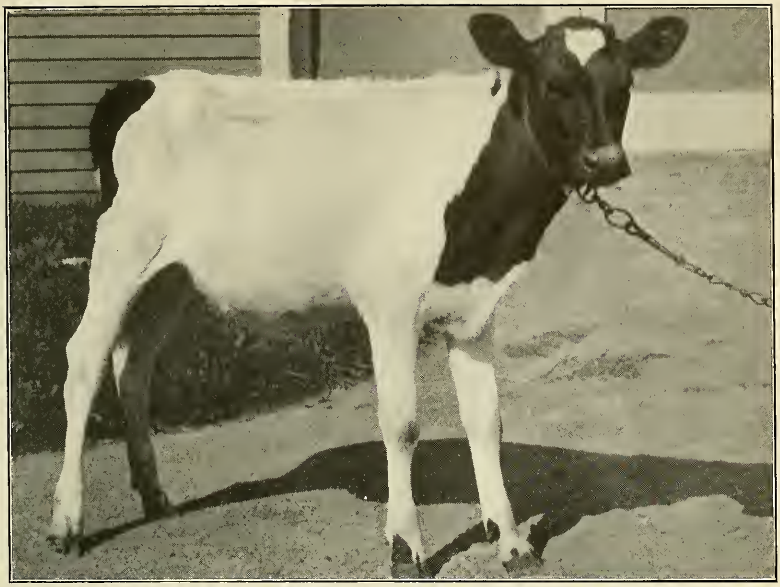

Fig. 5.— White. Lindsey's calf meal I.

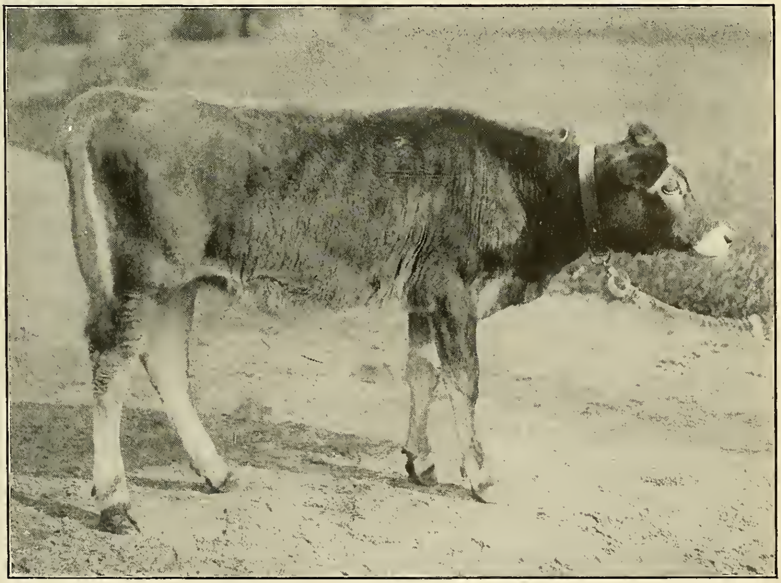

Fig. 6. — Jersey II. Lindsey's calf meal II.

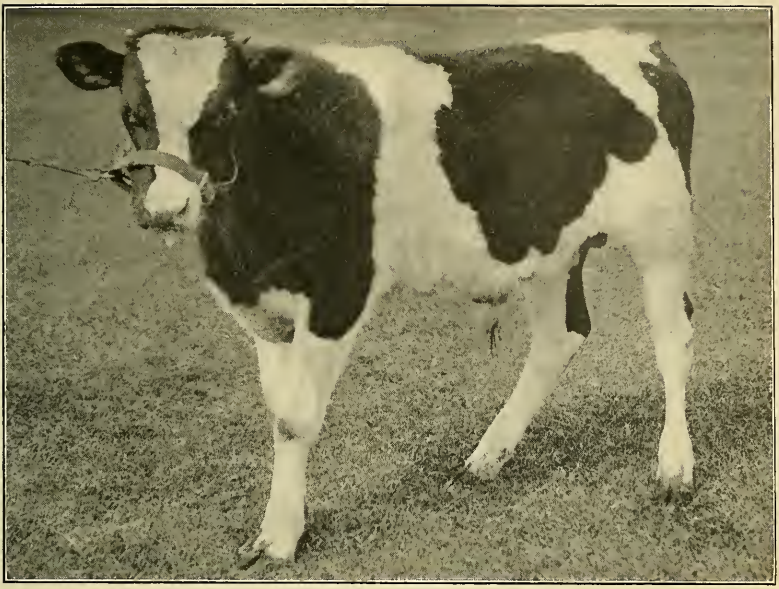

Fig. 7. — Holstein bull. Lindsey's calf meal III.

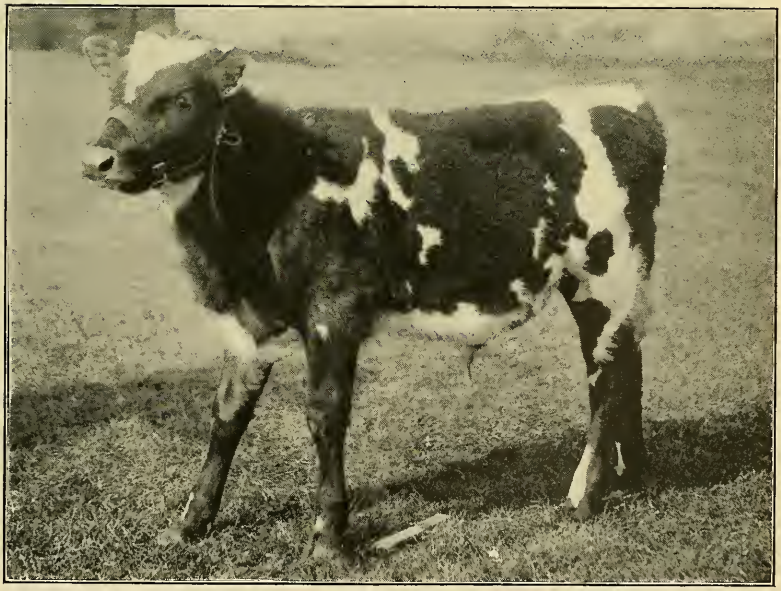

Fig. 8. — Ayrshire bull. Lindsey's calf meal IV.

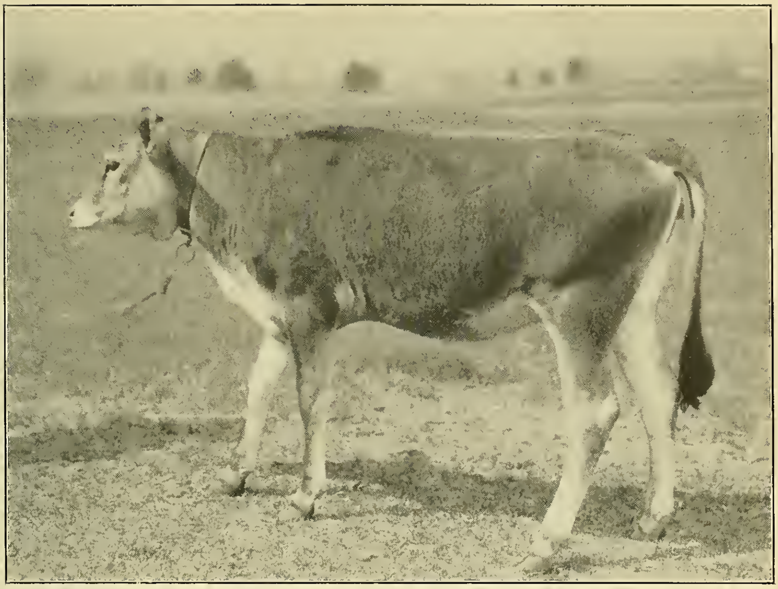

Fig. 9.—Red IV. Lindsey's calf meal V.

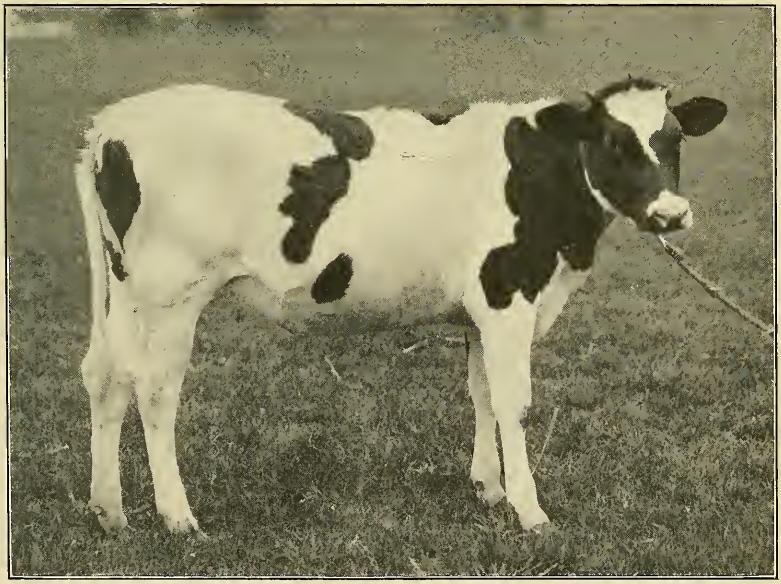

Fig 10.—Samantha III. Lindsey's calf meal VI.

Wing[1] fed the Blatchford meal to two Holstein and two Shorthorn calves, the average weight of the four at birth being 72 pounds. "The calf gruel was made by mixing the meal with a little cold water to avoid lumps, then enough hot water was added to make a sufficient gruel for the number of feeds required. The gruel was cooled and warmed again to 90° to 100° F. before feeding if too cold. When the meal was first fed to the young calf a tablespoonful of the meal was mixed into gruel in this way and added to the whole milk. The whole milk was then gradually reduced until the calf took the meal gruel entirely. The amount of calf meal fed per day varied from a tablespoonful, fed in the beginning with the whole milk, up to 2¼ pounds per day."

Results of Wing's Trials.

Calf Number.	Whole Milk (Pounds).	Blatchford's Calf Meal (Pounds).	Hay (Pounds).	Grain (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
2, ...	302	234	232	90	$16 83	11.4	148	.99	150
9, ...	213	268	290	90	17 00	15.7	108	.72	150
14, ...	144	273	407	130	17 26	13.2	131	.87	150
18, ...	168	306	303	125	18 39	13.5	136	.91	150

It is certain that in case of these four calves the gain per day is low and the food cost per day is high. Wing concluded that "Blatchford's Calf Meal, while good enough for raising fair-sized calves, is too expensive to feed ordinarily."[2]

V. Calves fed Bibby's Cream Equivalent.

This meal is prepared by J. Bibby & Sons, Liverpool, Eng., and contains, according to the manufacturer's statement, linseed and linseed cake, tapioca flour, sago flour, rice polish starch, locust bean and salt. From the high percentage of fat present considerable flaxseed meal must be used. Its cost is a trifle over 4 cents a pound. It was tried on three calves (one a delicate Jersey and two vigorous grade Holsteins). The Jersey calf was fed whole and skim milk for three weeks, at the end of which the calf-meal gruel was gradually added. Four quarts of skim milk were fed daily throughout the trial which lasted 164 days. The maximum amount of calf meal fed daily as gruel was 1 pound, 5 ounces.

The Holsteins were also given whole and skim milk for the first three weeks and then began the feeding of the calf gruel. The maximum amount of meal fed as gruel was 18 ounces daily. Four quarts of skim milk were fed daily throughout the trial, lasting 140 days. The gruel was prepared in the usual way by adding a little cold water to the dry meal and then approximately 1 quart of boiling water for each 3½ ounces of meal. The mixture was allowed to stand until cool, and was always warmed to 90° to 100° F. before feeding. In addition to the calf meal fed as a gruel, after the first three months the dry meal and rowen were placed before the animals and they soon began to eat these readily. At the end of the 140 days the calves were eating daily 4 quarts of skim milk, 18 to 21 ounces of calf meal as gruel, 8 ounces of dry calf meal and 5 pounds of rowen.

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[1] Already cited.

[2] Calf meal cost 4 cents a pound at the time.

Results.

CALF.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Cost (Dollars).	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Jersey, ...	133	1,420	168[1]	305	$15 11	8.4	179.5	1.13	164
Holstein, ...	106	1,237	125	235	12 51	7.1	174.5	1.30	140
Holstein, ...	112	1,240	112	230	11 62	7.1	163.0	1.20	140

[1] Thirty-six pounds of another calf meal.

The calves did very well on this diet and were in good condition at the end of the trial. It would have been more satisfactory, from an experimental standpoint, if they had been given rather more of the calf meal and less of the milk; they appeared, however, to be taking all of the meal that they could care for and keep in good condition.

VI. CALF MEALS PREPARED AT THIS STATION.

This station has compounded a number of calf meals and fed them to calves. The object was to use feedstuffs that were available in the ordinary markets at reasonable prices, and that were free from an excess of fiber and easily digested.

Lindsey's Calf Meal I.

Ingredients: —
10 pounds fine corn meal.
10 pounds flour middlings.
15 pounds flaxseed meal.
10 pounds cheap flour.
5 pounds glucose sugar.
1 pound salt.

Cost, 3.2 cents a pound.

The corn meal, flour middlings and cheap flour were easily obtainable. The flaxseed meal, procured of linseed oil manufacturers, was used because of the favorable effect of its protein and of its large percentage of fat. The glucose sugar was incorporated to impart a pleasing taste, and because it could be readily assimilated. This mixture was fed to two grade calves.

Results.

Calf.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Grade Holstein I., . .	211	935	185	256	$14 86	11.4	130.0	.90	149
Grade Ayrshire III., . .	120	1,467	189	199	14 21	9.4	150.5	1.04	144

The grade Holstein received, during the first part of the trial, 47 pounds of Schumacher's Calf Meal, and after that the station calf meal. It scoured badly when young, and hence did not make very satisfactory gains. The grade Ayrshire was not affected at all with scours and came along nicely. These calves received 5 quarts of skim milk and as high as 1 pound of calf meal as gruel daily. The calf meal was considered fairly satisfactory, although the cost of a pound of growth was too high. The glucose sugar is not on the market as a food for stock; it was procured through the Corn Products Refining Company of New York.

Lindsey's Calf Meal II.

Ingredients: —
25 pounds ground oat flakes.
15 pounds flaxseed meal.
8 pounds cheap flour.
2 pounds glucose sugar.
1 pound salt.

Cost, 3.7 cents a pound.

The oat flakes were the ordinary oat meal used for human food. It was purchased in bags of 96 pounds in weight.

Results.

Calf.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Pure Jersey II., ...	–	1,164	226	110	$12 40	7.2	172	1.03	167
Pure Jersey IV., ...	34	1,404	249	305	15 74	8.2	193	.90	203
Pure Jersey V., ...	63	1,530	233	248	15 90	7.4	214	1.20	180

Calves II. and IV. were pure-bred Jersey heifers sent by a breeder. They were some ten to fourteen days old when received, and it did not seem necessary to feed them much, if any, whole milk. Calf V. was a pure-bred Jersey bull. They received from 4 to 5 quarts of skim milk as a basal ration daily, and from 1 to 2¼ pounds of calf meal daily as gruel. Calf II. underwent a severe attack of indigestion at the close of the experiment, lost her appetite and became quite emaciated. It was necessary to put her on an entire diet of skim and whole milk for a month in order to restore her to normal condition. The cause of the trouble was not clear.

Lindsey's Calf Meals III. and IV.

Ingredients of III.: —
8 pounds fine corn meal.
10 pounds flour middlings.
14½ pounds flaxseed meal.
10 pounds cheap flour.
7 pounds glucose sugar.
½ pound salt.

Cost, 3.4 cents a pound.

This meal differed from I. in the increase of the glucose sugar, to note if the additional sugar had any ill effect on the nutrition of the calf.

Ingredients of IV.: —
10 pounds fine corn meal.
10 pounds flour middlings.
14½ pounds flaxseed meal.
15 pounds cheap flour.
½ pound salt.

Cost, 3 cents a pound.

This meal differed from the preceding in the removal of the glucose and in the increase of the flour.

Results.

CALF.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Grade Holstein VI.,[1] . .	60	1,584	237	210	$15 24	6.1	251	1.70	148
Grade Ayrshire VII.,[2] .	68	1,670	230	200	14 49	6.5	224	1.50	148

[1] Bull fed calf meal III.

[2] Bull fed calf meal IV.

Both calves did well, and no adverse effect of the glucose was noted in case of Calf VI. The calves each received 5 quarts of skim milk daily until they were 120 days old, when the amount was reduced to 3 quarts daily. During the fifth month they received as high as 2½ pounds of calf meal daily as a drink. They were both very vigorous calves, and while they suffered at times from slight attacks of scours, they grew rapidly.

Lindsey's Calf Meal V.

This meal was made so that it contained a fairly liberal amount of ground oat flakes and some flaxseed meal, together with flour middlings and corn meal. The flaxseed, being expensive, was reduced somewhat from the amount used in the other meals, and the blood flour was incorporated as a check to scours.

Ingredients: —
22 pounds ground oat flakes.
10 pounds flaxseed meal.
5 pounds flour middlings.
11 pounds fine corn meal.
1½ pounds prepared blood flour.
½ pound salt.

Cost, 3 cents a pound.

Results.

CALF.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Ida II., ...	52	1,658	219	395	$14 69	7.2	203	1.10	188
Red IV., ...	108	1,440	229	385	15 60	8.3	188	1.20	171
Betty III., ...	128	943	230	401	14 68	7.9	186	1.19	156
Colantha, ...	119	1,229	229	440	15 50	7.1	218	1.50	142

The first two calves were Jerseys, the next a grade Ayrshire, and the last a high-grade Holstein. Ida II. was fed 4 quarts of skim milk and as high as 21 ounces of calf meal daily as gruel. During the last month of the trial she also consumed 1 pound of dry calf meal a day. She was a thrifty calf, and although she suffered from two short attacks of scours, she did well during the entire trial. Red IV. received daily 4 quarts of skim milk and as high as 20 ounces of calf meal in water. She also ate 1 pound of the dry meal daily during the final month. She was not affected with scours and grew steadily. Betty III. received but 3 quarts of skim milk daily after the first two months. She consumed as high as 1½ pounds of moist calf meal daily, and also 1 pound of the dry meal per day for the last month. She was a very thrifty calf. Colantha was given 4 quarts of skim milk each day. She also consumed a maximum of 1¼ pounds of moist calf meal daily and 1½ pounds of dry meal daily for the last month. She was a vigorous calf and was not troubled with scours.

Lindsey's Calf Meal VI.

Ingredients: —
35 pounds ground oat flakes.
12½ pounds barley malt.
1½ pounds blood flour.
½ pound bicarbonate of potash.
½ pound salt.

Cost, 3.3 cents a pound.

The malt is intended as a food and also to act upon the starch in the oats and convert it partly to maltose, in which form the oats are more easily digested. This combination is made after the formula of Liebig,[1] only oat meal is substituted for wheat meal. Our method of preparation was as follows: The malt was kept separate from the other ingredients. Three ounces of the oat meal-blood-potash mixture were converted into a paste with cold water, and then sufficient water added to make 1 quart, and enough prepared at one time for each twenty-four hours. This mixture was cooked or heated very warm for fifteen minutes and then cooled to 100° to 120° F. One ounce of ground malt was then added for each quart of the first mixture, and the latter allowed to stand for one-half hour. It was heated again to near boiling, then cooled and fed milk-warm. The basal ration of skim milk was added just before feeding. The reason for heating to near boiling or to boiling before adding the malt is to gelatinize the starch, which enables the malt to act on it more thoroughly.

Results.

CALF.	Whole Milk (Pounds).	Skim Milk (Pounds).	Calf Meal (Pounds).	Rowen (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).	Total Gain (Pounds).	Daily Gain (Pounds).	Days in Trial.
Samantha III., ...	113	1,397	191	310	$14 64	7.2	202	1.33	151
Samantha IV., ...	135	1,357	203	220	14 98	7.7	194	1.22	159
Colantha II., ...	167	1,361	305	400	19 99	7.8	255	1.50	160

All three were thrifty grade Holsteins. Samantha III. received 4 quarts of skim milk daily and as high as 1½ pounds of calf meal as gruel, and 1 pound of dry meal daily. Samantha IV. received 5, 4 and 3 quarts daily of skim milk as the trial progressed. During the latter part of the trial she consumed the same amounts of calf meal daily as did Samantha III. Colantha II. received 4 quarts of skim milk daily, as high as 1½ pounds of calf meal as gruel, and the same amount of dry calf meal daily. She was an exceptionally vigorous calf.

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[1] Kellner's Ernährung, etc., sixth edition, p. 283.

Tabular Summary of All Trials.

Kind of Ration.	Number of Calves.	Days in Trial.	Daily Gain (Pounds).	Total Food Cost.	Cost of Food per Pound of Gain (Cents).
Skim milk in large supply, ordinary grains and hay.	10	235	1.22	$22 08	7.7
Skim milk and Hayward's Calf Meal (Lindsey).	2	173	1.23	20 44	9.6
Whole milk and Hayward's Calf Meal (Hayward).	12	102	1.18	11 34	9.6
Skim milk, Schumacher's Calf Meal (Lindsey).	3	150	1.00	12 27	8.2
Whole milk and Schumacher's Calf Meal as per directions (Wing).	10	132	1.19	13 16	8.5
Skim milk and Blatchford's Calf Meal (Lindsey).	1[1]	–	1.15[1]	–	–
Whole milk and Blatchford's Calf Meal (Wing).	4	150	.87	17 37	13.5
Whole and skim milk and Bibby's Cream Equivalent (Lindsey).	3	148	1.21	13 08	7.5
Whole and skim milk and Lindsey's meal I.	2	147	.97	14 54	10.4
Whole and skim milk and Lindsey's meal II.	3	183	1.04	14 68	7.6
Whole and skim milk and Lindsey's meal III.	1	148	1.70	15 24	6.1
Whole and skim milk and Lindsey's meal IV.	1	148	1.50	14 49	6.5
Whole and skim milk and Lindsey's meal V.	4	164	1.25	15 12	7.6
Whole and skim milk and Lindsey's meal VI.	3	157	1.35	16 54	7.6
Average (calf-meal calves), . . .	48	139	1.17	$13 90	9.0

[1] Not included in the average.

Comments on the Results.

The above table shows that in case of 10 calves fed during the first 235 days, or 7.8 months, of their lives on a small amount of whole milk, liberal amounts of skim milk, mixtures of ordinary grains and what rowen they would consume, the average food cost was $22.08, the food cost per pound of gain was 7.7 cents, and the average daily gain was 1.22 pounds.

In case of 48 calves fed during the first 139 days, or 4.6 months, of their lives on a little whole milk, together with calf meals, or with a little whole milk, 4 to 5 quarts of skim milk per day, calf meals and what rowen they would eat, the average food cost was $13.90, with variations of from $11.34 to $20.44; the cost of food per pound of gain was 9 cents, with variations of from 6.1 to 13.5 cents; and the average daily gain was 1.17 pounds, with extremes of .87 pound and 1.70 pounds.

These results indicate that calf meals may be purchased or prepared that will take the place of a considerable amount of whole or skim milk and not interfere with the normal growth of the calf. It is doubtful, however, if one will be able to find any article or combination of articles that will completely take the place of milk during the first two or three months of the calf's life. In case of the writer's own observations with different calf meals he did not think it advisable to attempt to rear the calves during the first four months without the use daily of 3 to 5 quarts of skim milk. A too early attempt to accustom the calf to an exclusive diet of calf meal is likely to produce digestive disturbances that may affect the health of the animal in after life. Young calves differ in their ability to take and utilize foods other than milk, and the careful observation and judgment of the feeder are at all times necessary. Holstein and Ayrshire calves are, as a rule, better able to utilize prepared foods than are the Jersey and Guernsey, although we have had no serious trouble in rearing calves of the latter breeds with a minimum of milk.

Our experiments have shown that we have found some proprietary meals, as Schumacher's and Bibby's, satisfactory as partial milk substitutes. Of our own preparations, Nos. V. and VI. have given very good results. Other calf meals on the market not tested by us may also be equally satisfactory. The special characteristics of a satisfactory calf meal will be discussed under the heading of "Composition of Calf Meals."

It is admitted that it is not very convenient for the dairyman rearing a few calves each year to attempt to prepare his own calf meals, especially if it is necessary to send out of town for some of the ingredients. In such cases it is more desirable to purchase the prepared article, providing one is found that will prove satisfactory. Suitable calf meals ought not to exceed 3 cents a pound in price.

How to feed the Young Calf.

Without recommending any preparation in particular, the writer takes this opportunity to outline the method for feeding the young calf in case it is desired to get along with as little milk as possible.

1. Allow the calf to remain with the dam as a rule for two or three days. In case of Jersey or Guernsey calves it may be necessary to shorten the time because of the laxative effect of such milk.

2. The calf should be kept in a *clean* pen and well bedded. Damp, dirty quarters are to be avoided.

3. The pail out of which the calf is fed, as well as all utensils, must be kept clean. This is vital.

4. At the end of the second or third day begin to teach the calf to drink warm whole milk. That with a low fat percentage (4 or less) is preferable to a richer article. From 4 to 6 quarts daily is sufficient for the first two weeks, the amount depending upon the vigor and size of the calf. It is better to feed three times daily during this time, but not necessary.

5. After the first two weeks warm skim milk can gradually be substituted for the whole milk, and in case of vigorous calves, within a week or ten days thereafter the substitution may be completed.

6. At the end of the second, or possibly the third, week (judgment to be used in all cases), a quart of the calf-meal gruel may be added. This substitute is best prepared, in the opinion of the writer, by using $3\frac{1}{2}$ to 4 ounces of meal to each quart of water. The meal is first stirred with a little cold water to get out the lumps and to convert it into a paste. A quart of boiling or very hot water is then added, and the mixture thoroughly stirred and allowed to stand until milk-warm, in which condition it is fed, preferably mixed with the milk. Neither milk nor calf-meal gruels should be fed cold, but milk-warm. The quantity of skim milk can be reduced to 4 quarts daily, and the quantity of calf-meal gruel gradually increased until the animal is receiving 4 to 6 quarts a day of the latter, depending upon its ability to utilize it.

7. At the end of three months the skim milk can be reduced to 3 quarts, or possibly to 2 quarts, daily if necessary. Before this time the animal should be taught to eat the calf meal dry, by placing some of it in a box fastened to the wall, and at first placing a little in its mouth and rubbing the meal upon its nose. Rowen or fine hay should also be placed before the calf in a little rack, and it will soon learn to take it.

8. At the end of four months the skim milk may be entirely withdrawn and a few weeks later the calf-meal gruel, for by this time the animal should be eating considerable dry meal and hay. Naturally, if skim milk is available it is worth while to feed it until the calf is six months of age, it proving very helpful in increasing growth. Feeders wishing to secure large animals frequently feed skim milk until the animal reaches eight months or even twelve months of age; they also defer breeding until the calf is one year, nine months old.

9. After the calf is five months old, if in good condition, the calf meal can be entirely removed and an ordinary grain mixture substituted, consisting, by weight, of one-third ground oats, one-third wheat bran and one-third corn or hominy meal; or wheat middlings may be substituted in the mixture for ground oats. The roughage may consist of one-half to one peck of silage and what rowen or fine hay the animal will clean up. Emphasis is placed upon the fact that absolutely definite rules relative to the time of substituting the different foods cannot be given, so much depending upon the condition of the calf. The close observation and good judgment of the feeder are very necessary if the full measure of success is to be attained.

10. In case of scours, or if the animal begins to show a fickle appetite, the best remedy is to cut down the food supply one-half or even two-thirds in amount. Do not overfeed in any case. The calf should always have an appetite for more than the amount given to it.

11. In case of our own calf-meal preparations, Nos. V. and VI. are to be preferred. For the preparation of VI. see special instructions on page 60.

THE CHEMICAL COMPOSITION OF MILK AND CALF MEALS.

The following tables show the relative proportion of the several chemical groups in calf meals as compared with whole and skim milk, the latter with their natural water content, and also reduced to a 10 per cent. water basis for easier comparison with the various calf meals: —

(*a*) *Milk.*

	Water.	Ash.	Fiber.	Protein.	Extract Matter.	Fat.
Natural milk, ...	87.5	.70	–	3.30	4.80[1]	3.70
Milk on 10 per cent. water basis, .	10.0	5.00	–	23.76	34.56[1]	26.64
Skim milk, deep-setting process, .	90.8	.70	–	3.30	4.88[1]	.32
Skim milk on 10 per cent. water basis,	10.0	6.85	–	32.28	47.78[1]	3.13

(*b*) *Calf Meals in Trials.*

	Water.	Ash.	Fiber.	Protein.	Extract Matter.	Fat.
Hayward's,[2]	–	–	–	–	–	–
Schumacher's, ...	9.34	2.22	1.52	17.15	62.29	7.48
Blatchford's, ...	10.42	5.13	6.03	24.91	48.56	4.95
Bibby's, ...	7.99	6.23	4.90	16.78	49.68	14.42
Lindsey's, I., ...	7.37	3.30	2.78	14.98	58.99	12.58
Lindsey's, II., ...	7.34	3.50	2.93	20.89	56.34	9.00
Lindsey's, V., ...	6.84	3.55	2.34	17.08	57.64	12.55
Lindsey's, VI., ...	7.34	3.50	2.14	16.29	65.27	5.46

(*c*) *Other Calf Meals.*

	Water.	Ash.	Fiber.	Protein.	Extract Matter.	Fat.
Clover Leaf Calf Meal, ...	10.78	4.43	5.55	25.31	48.53	5.40
Ryde's Cream Calf Meal, ...	11.30	4.67	4.50	23.82	51.03	4.68
Sugarota, ...	10.33	4.36	3.72	25.35	50.51	5.73

[1] Milk sugar.

[2] Not analyzed.

Reduced to a 10 per cent. water basis, it will be noted that whole milk contains nearly 24 per cent. nitrogenous matter (protein), some 26 to 27 per cent. fat, and over 30 per cent. milk sugar. Skim milk on the same basis contains over 30 per cent. protein, nearly 50 per cent. sugar and a little over 3 per cent. fat.

Many of the various calf meals are made, so far as the relative proportions of the several ingredients are concerned, to imitate dry skim milk. Thus Blatchford's Calf Meal contains 24 or more per cent. of protein, 48 per cent. of extract matter and about 5 per cent. of fat. The Bibby meal, on the other hand, contains noticeably less protein and considerably more fat. The calf meals prepared by this station contained from 15 to 20 per cent. of protein and from 5 to 12 per cent. of fat. All of the meals, with the possible exception of Bibby's, contained noticeably less ash than that contained in the skim milk, and most of them too much fiber. It is believed that the fiber content should be kept at a minimum, *i.e.*, not over 3 per cent.

In our own case we have refrained from making a mixture with over 20 per cent. protein, for the reason that it was feared the calf would find difficulty in caring for a larger amount. It must be remembered that the protein of milk exists in solution as casein and lactalbumin, — easily digested and assimilated forms of nitrogen, — while the protein in the different grains is in forms not so easily utilized by the young animal. The writer sees no objection to a meal containing 12 per cent. of fat, providing it can be economically incorporated. The high price of flaxseed meal, the usual source of fat, renders its use in very large amounts of doubtful economy. It is probable that a higher ash percentage than 3 per cent. may prove helpful, but it would have to be made artificially and incorporated, as most of the grains employed do not contain more than that percentage. If a minimum of 3 to 4 quarts of skim milk is fed each day for the first three months, the 3 per cent. of ash in the calf meal would probably prove sufficient.

In preparing a calf meal the object should be to use only those ingredients that are easily and highly digestible, and at the same time are not too expensive. Among such feeds may be mentioned finely ground corn meal, flour middlings, ground rice, wheat flour, oat flakes, barley malt, cocoanut meal and flaxseed meal. Cottonseed meal in any quantity is not advised; oat flakes and malted grains seem to be quite satisfactory. Dry skim milk is a valuable substance, but its cost is likely to prevent its use. It is doubtful if aromatics such as fenugreek and anise are of any special value. The use of carob bean meal (St. John's-bread) imparts a sweet taste to the calf meal. Its value as compared with its cost is unknown to the writer.

PART II.

THE COST OF REARING A DAIRY COW.

FOOD COST.

As explained in the first part of this bulletin, the station for the past ten or more years has made a practice of raising its own dairy stock. It is intended in what follows to show the complete food cost of the heifer from the time it was dropped until it reached the age of two years. The labor and other costs are also quoted from an authentic source.

Some of the calves, until they were six to eight months of age, were developed on skim milk, grain and hay, while others received small amounts of whole milk, 4 to 5 quarts daily of skim milk, calf meal and hay. The calves were usually dropped in the autumn, and fed as previously outlined until May, when they were sent to pasture, and returned to the feeding barn some time in October. During the late autumn, winter and early spring they were given such roughage as corn fodder, one peck to one-half bushel of silage daily if the same was available, and what hay they would eat. In case silage was not on hand rowen or fine hay was supplied, care being taken to give no more daily than would be fully consumed. They were fed also 2 to 3 pounds of a grain mixture daily, composed, by weight, of one-third wheat bran, one-third corn or hominy meal or wheat middlings, and one-third gluten feed; or one-fourth wheat bran, one-half corn or hominy meal, and one-fourth cottonseed meal. In some cases other grain mixtures were supplied, depending upon cost and availability. They were usually bred when fifteen to twenty months of age, sent to pasture a second summer, and, on return, fed as previously indicated, excepting that if not at pasture the grain ration was increased in amount, in some instances, to 5 pounds daily during the last three or four months previous to calving, in order to bring them into good physical condition and to aid in the development of the milk glands. During the winter months they were carded daily, and usually turned into the barnyard for a number of hours each day in pleasant weather. Here follows a tabulated statement of the food cost. In the table P. B. means pure bred, G. means grade, A. H. J. and G. mean Ayrshire, Holstein, Jersey and Guernsey, respectively. It might be added that the station herd has consisted mostly of grade Jerseys, with a few pure breds, although of late some grade Holsteins and a number of grade Ayrshires have been added. The herd has been kept for the purpose of studying the nutritive effect of different feeds and feed combinations upon the production and cost of milk, and not maintained as a herd for economic dairying. At the same time, it has been our object to keep only profitable milk producers. The grade cows were bred to pure-bred bulls, and only those heifers raised which gave promise of developing into satisfactory dairy cows. In making the following tabulation the costs of the various feeds were: hay $10, silage $4.50, green feed $3.50 and grain mixtures $32 a ton. The value placed upon the milk and calf meal was the same as stated in the first part of this bulletin. Pasturage was charged at 25 cents a week for the first summer, and 30 cents for the second summer. In a few cases the animals, for some reason, did not go to pasture for one summer, but were soiled, which resulted in a higher food cost. The hay was charged at a price approximating cost, rather than at market value. For the sake of comparison it was thought best to determine the food cost at two years of age in each case, rather than at time of calving which, of course, varied. The calves were raised in different years, and primarily to keep up the herd, hence in some cases, especially if the animals were at pasture, we did not have the live weight when the animals were exactly two years old.

NAME.	Breed.	Weight when Two Years Old (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).	Cost of Feed (Dollars).	Cost of Feed per Pound Gain (Cents).
Maud,	G. G.	780[1]	710	.88	61.80	-
Amy of W.,	P. B. J.	635[2]	575	.73	49.71	-
O. Amy,	P. B. J.	-	-	-	56.23	-
Betty,	G. J.	730	670	.92	60.05	8.96
Red III.,	G. J.	680	615	.84	56.02	9.11
Susie,	G. J.	650[3]	600	.74	78.79[3]	-
Lena,	G. J.	-	-	-	55.75	-
Mibbs,	G. J.	725[4]	665	.84	68.81	-
Daisy II.,	G. J.	675	620	.85	49.54	7.99
Ida,	P. B. J.	735[5]	-	-	53.32	-
White,	G. H.	900[6]	815	1.04	65.25	-
Amy II.,	P. B. J.	600[7]	555	.72	46.84	-
Fancy III.,	G. J.	683	623	.85	54.85	8.80
Samantha II.,	G. H.	900[8]	820	.93	58.03	-
Betty II.,	G. A.	745	685	.94	58.98[9]	8.61
Betty III.,	G. A.	725[10]	655	.91	48.44	-
Ida II.,	P. B. J.	746	689	.94	53.78	7.81
Cecile II.,	P. B. J.	600	557	.76	58.89	10.57
Samantha III.,	G. H.	-	-	-	63.07	-
Red IV.,	G. J.	615[11]	542	.88	56.42	-
Average,	-	713	-	.86	57.73	-

[1] Eight hundred five days.

[2] Seven hundred eighty-six days.

[3] Eight hundred thirteen days. High cost due to soiling one season.

[4] Seven hundred ninety days.

[5] Eight hundred fifty-seven days. Calf purchased when three months old; food record for two years from date of purchase.

[6] Seven hundred eighty-two days.

[7] Seven hundred seventy days.

[8] Eight hundred eighty-four days.

[9] High cost due to soiling one season.

[10] Seven hundred sixteen days.

[11] Six hundred eighteen days, last weight.

It will be seen that the animals, most of which were grade Jerseys, varied in live weight from 600 to 900 pounds, the latter being the weight of a thrifty grade Holstein heifer. The average weight was 713 pounds, and the daily average gain .86, or a little less than a pound a day for the first two years.

The food cost varied from $46.84 to $78.79, the latter cost being due to the fact that the heifer was soiled one season. The food cost of two thrifty grade Holstein heifers was $58.03 and $63.07, respectively, and the average cost of the 20 heifers was $57.73.

Several of the heifers did not prove satisfactory and were disposed of; for instance, Maud and Mibbs were poor producers, O. Amy and Lena failed to breed, Susie developed tuberculosis, and Daisy II. aborted. The prices secured for these discards are, unfortunately, not available, but a fair estimate would be about $140, which, deducted from the total food cost of the 20, — $1,154.57, — would leave $1,014.57, this sum being the cost of the 14 good ones remaining; or an average cost of $72.47. The discarding of 30 per cent. of the 20 heifers raised seems large, and it is doubtful if it would hold true in most cases. The results, however, are presented as secured. It is known that in spite of the best judgment in the rearing of dairy animals a considerable loss is experienced through one cause or another.

Trueman,[1] in a detailed feeding record of one Guernsey, two Jersey and two Holstein heifers, shows that the average food cost of each heifer at two years of age was $55.[2] He calls attention to the fact that "a certain number will fail to be good producers, and will have to be discarded at a loss," but presents no data on this subject.

Morse [3] in 1898 has shown that the food cost of raising dairy heifers to sixteen months of age averaged $28.81 each. This, however, was at a time when the cost of feed was very much less than at present.

Bennett [4] and Cooper [4] present exceedingly interesting data on the entire subject in a publication entitled, "The Cost of Raising a Dairy Cow." They co-operated with C. I. Brigham on his private farm located in Wisconsin. The dairy farm contained 50 Jersey cows and about 40 head of young stock. The observations covered a period of five years, during which time 117 calves, some of which were bulls, were under observation. The average food cost of the 73 heifers that reached maturity was $40.83, the cost of the different articles of feed being below that charged in our own experiment.[5] As nearly as can be ascertained from the bulletin, of the 86 *heifer* calves on trial during the five years, 73 were brought to maturity, 2 died and 11 were discarded, a loss of 15.1 per cent.

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[1] Bul. 63, Storrs Exp. Sta.

[2] Whole milk $2 and skim milk 25 cents a hundred pounds; hay $12, silage $4, and grain $30 a ton; pasture $2 and $4 a season.

[3] Bul. 58, N. H. Exp. Sta.

[4] Bul. 49, U. S. Department of Agriculture, 1914.

[5] Whole milk $1.50 to $1.60 a hundred; skim milk 20 cents a hundred; bran and corn $22 to $25, oats and barley $25, linseed meal $35 to $41, hay $8 to $10, alfalfa $12 to $15, corn stover $4, silage $4 per ton; pasture 10 to 20 cents a week.

OTHER COSTS.

Because of our method of raising the calves (a few each year), it was not possible to get at the other items entering into the total cost of the two-year-old heifers. Trueman makes an estimate, while Bennett and Cooper are able to present exact data, of which the following is a summary: —

Cost (Other than Food) of Two-year-old Heifer.

	Bennett and Cooper.	Trueman (estimated).
Labor,	$8 00	$10 00
Interest on value of heifer,	3 65	-
Interest on buildings,	2 38	-
Interest on equipment,	55	-
Bedding,	3 00	2 00
General expense,	2 93	4 00
	$20 51	$16 00

The man labor was charged on the Brigham farm at 12 cents, and the horse labor at 10 cents, an hour; interest on the value of the heifer during the first and second years at 5 per cent., interest and depreciation on the barn at 8 per cent., interest and depreciation on equipment, such as steam boilers for heating milk, feeding pails, cans and the like, 20 per cent. The term "general expense," as used by Bennett and Cooper, was meant to include a general overhead expense of the entire farm business, which on the Brigham farm was 5 per cent. of the located expense. The manure from the calf for the two years was assumed to be worth $8 on the Bennett farm and $5 by Trueman. The former assumes, therefore, that the cost of labor is offset by the value of the manure. It would seem to the writer that the labor cost, and probably the interest and depreciation on buildings, would be somewhat greater in Massachusetts than is allowed in Wisconsin.

INITIAL VALUE OF HEIFER.

The Brigham farm considered the initial value of its pure-bred heifer calves to be $7. In our own case we should think that $4 would be near the average value of grade dairy heifers when dropped. Putting the figures available together, we have the following: —

Total Cost of the Two-year-old Heifer.

	Bennett and Cooper (Wisconsin).	Trueman (Connecticut).	Lindsey (Massachusetts).
Initial value of heifer,	$7 00	$4 00[1]	$4 00
Food cost,	40 83	55 00	57 73
Other costs,	20 51	16 00	20 51
Total,	$68 34	$75 00	$82 24
Credit by manure,	8 00	5 00	8 00
Total net cost,	$60 34	$70 00	$74 24

[1] Added by Lindsey.

The writer has adopted the Wisconsin "overhead charge" because it is the best available, and because it is based on careful observations. If anything, it is below rather than above the actual cost in Massachusetts. These "other costs" and "overhead charge" do not include the loss or shrinkage due to death, disease and poor milking qualities of heifers in the process of raising or on arriving at the milking stage. In raising 20 heifers we discarded 6, or 30 per cent., which was probably above the average loss. On the Brigham farm 15 per cent. were discarded during the two years of growth, but, owing to fortunate methods of disposing of them, the loss on the 73 head remaining prorated only 42 cents a head, which was exceedingly small. Our cash loss per head on the 14 heifers remaining on the basis of food cost was $14.53, due partly to the fact that the animals had reached the age of two or more years before the discard was made.

The sum of $10 per head, in the judgment of the writer, would not be an excessive average figure to allow for loss due to discarding in the rearing of dairy heifers until they come into milk. In some cases the loss may be greater, while in other cases scarcely anything, but in a series of years a noticeable shrinkage is bound to occur. Adding this to our net cost of $74.24 brings the amount to $84.24 as the total cost of raising an average heifer weighing 713 pounds to two years of age. If this figure seems exceedingly high to many they should consider the various data given, and note in what particulars they think the charges excessive.

All things considered, the writer is of the opinion that $75 to $85 represents the cost of raising the average dairy heifer until she reaches the age of two years.

Trueman, as a result of his observations, states: —

> Considering all these factors (feed, labor, interest, taxes, barn room, discarding, etc.), it is doubtful if good heifers can be raised and put to work in the herd for much under $80 each. Good heifers are not dear at that price, however. They are young and vigorous and ready for a long life of usefulness, and are cheaper at that price than the average cows bought at maturity for $60.

Bennett and Cooper say that the "cost of producing a dairy heifer seems to indicate that a heifer entering the dairy herd at two years of age must be worth at least $60 to cover cost only.[1] It would appear that a farmer cannot afford to raise a heifer calf that will not sell for more than $60 at two years of age."

Concluding Suggestions.

1. The above data make it very clear that too much care cannot be used in the selecting of heifer calves for dairy cows. They should be sired by bulls of known reputation and be dropped by large producing cows. Heifers from unknown bulls or from inferior cows are not worth the raising.
2. As small an amount of milk should be used as is consistent with a satisfactory growth of the calf, because of the relatively high cost of both whole and skim milk. Of the total food cost, in case of our own experiments, milk represented from 11 to 35 per cent., with an average of 20.5 per cent. In case of the Wisconsin trials milk represented one-third of the total food cost.
3. Calf meal will serve as a partial milk substitute, but at 3 cents a pound, the 3½ ounces necessary to make a quart of the substitute cost two-thirds of a cent, and at that figure the skim milk is to be preferred; hence, if skim milk can be had at not over two-thirds to three-fourths of a cent a quart, it is to be preferred to calf meal at 3 cents a pound.
4. The calves should be pastured for two seasons whenever possible, and the pasture should not be overstocked. It frequently happens that owing to overstocking or to dry weather the young animals make but little growth during the pasture season, and it requires several months of barn feeding to bring them into a thrifty growing condition.
5. It is rarely advisable to leave the animals in the pasture after October 15. In case of early hard frosts it is better to bring them in October 1.
6. During the remainder of the year the most economical feeds are likely to be silage, early cut hay, possibly some cut corn stover, and 2 to 3 pounds daily of a standard grain mixture. The grain may be increased to 5 pounds daily three or four months before calving, whenever practicable, in order to aid in developing the milking qualities of the future cow.
7. An effort should be made to provide low-cost but comfortable winter quarters, dry and clean surroundings and convenient arrangements in order to keep the labor cost at a minimum.

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[1] The food cost of the Wisconsin heifers, due primarily to the less cost of many feeds during the experiment, was some $16 less than the Massachusetts cost. If this extra cost was added to the $60, it would bring the total up to $76, not including loss through discards.

THE EFFECT OF SULFATE OF AMMONIA ON SOIL.

R. W. RUPRECHT AND F. W. MORSE.

Introduction.

This bulletin is a record of efforts to determine the changes which the long-continued use of sulfate of ammonia has produced in soils.

The action of ammonium sulfate on soils has received attention in one way or another for many years. Among the first workers who used this salt in experiments was Way[1] (1850). In studying the absorption of ammonia by soils he found that soils had the power to absorb the ammonia from ammonium sulfate, but left the acid radical in solution in combination with another base, generally calcium. Voelcker[2] continued the work of Way and confirmed his results. Beyer,[3] in studying the absorption with potassium and ammonium chlorides, found that the ábsorption was dependent on the amount of iron and aluminium oxides present in the soils, and that the quantity of calcium and magnesium removed was almost equivalent to the potassium absorbed. Morse and Curry,[4] in working on clay with potassium and sodium salts, found that the bases were absorbed, and that in exchange calcium, magnesium, iron and aluminium were removed. In the presence of lime and carbonate of lime the iron and aluminium were precipitated.

Other workers[5] who studied the absorption but used different salts found the same general principle to hold true, namely, that the soil has the power to absorb the basic part of the salt, but that this power does not extend to the acid radical.

As to the results due to fertilization with ammonium sulfate we may cite the following investigators: —

Lawes and Gilbert,[6] in studying the drainage waters from differently fertilized plots, found that the plots treated with ammonium sulfate had much larger amounts of calcium removed than the other plots. They reached the conclusion that all of the sulfuric acid from the ammonium sulfate was removed as calcium sulfate. Wheeler[7] found that the long-continued use of ammonium sulfate brought the soils into an acid condition which could be corrected by liming. Hall and Miller[1] found that when ammonium salts were used as a fertilizer the loss of calcium carbonate was equivalent to the acid of the ammonium salt used. Nitrate of soda and manure diminished this loss of calcium. Hall and Gimingham[2] state that the continuous application of ammonium salts brought soils into an acid condition, and that the reaction was a double decomposition between calcium humate and the ammonium salts. In a later publication Hall[3] states that the acidity was caused by micro-fungi in the soil, which split up the ammonium sulfate to obtain the ammonia, thereby setting free sulfuric acid. Hunt[4] found that an acid condition, proving especially harmful to corn and clover, resulted from the continued application of ammonium sulfate.

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[1] Way, Jour. Roy. Agr. Soc., Vol. 11 (1850) and Vol. 13 (1852).

[2] Voelcker, Jour. Roy. Agr. Soc., Vols. 21, 60 and 62.

[3] Beyer, Ann. der Landwirtschaft, Bd. I. and II.

[4] Rept., N. H. Agr. Exp. Sta., 1906–08, p. 274.

[5] Frank, Salomon, Biedermann, Neutler, Knop, Frey, Pillitz, Kellner and Van Bemmelen.

[6] Lawes and Gilbert, Rothamstead Memoirs, Vol. 5, p. 97.

[7] Wheeler, Ann. Rept., R. I. Exp. Sta., 1893.

The conditions produced by the continuous application of ammonium sulfate on crops, as reported by these investigators, are very similar to the conditions on the nitrogen field at this experiment station.

Soil used in the Experiments.

The soil used for the various experiments herein described was taken from one of the oldest fields on the station farm. A record of this field has been kept for thirty-three consecutive years, and in that time it has received only chemical fertilizers. Since 1890, when the present scheme of fertilizing was inaugurated, the field has been used to compare different forms of nitrogen fertilizers. The plots are one-tenth acre in area and have a 2-inch tile drain running through the center of each plot at an average depth of 3 feet.

The chemicals applied since 1890 to the plots studied have been as follows: —

Table I. — *Chemicals applied annually.*

Plot 0.	Manure, dissolved bone black, sulfates of potash and magnesia.
Plot 1.	Nitrate of soda, dissolved bone black, muriate of potash.
Plot 5.	Sulfate of ammonia, dissolved bone black, sulfates of potash and magnesia.
Plot 6.	Sulfate of ammonia, dissolved bone black, muriate of potash.
Plot 7.	No nitrogen, dissolved bone black, muriate of potash.
Plot 8.	Sulfate of ammonia, dissolved bone black, muriate of potash.

The amounts applied have been 45 pounds of nitrogen per acre in nitrate of soda, sulfate of ammonia or manure, 80 pounds of phosphoric acid per acre in dissolved bone black, and 125 pounds of potash per acre in muriate of potash or double sulfates of potash and magnesia. On plot 0 the phosphoric acid and potash naturally present in the manure have been supplemented by enough chemicals to make 80 pounds of phosphoric acid and

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[1] Hall and Miller, Proc. Roy. Soc., Ser. B 77, No. B 514.

[2] Hall and Gimingham, Jour. Chem. Soc., Vol. 91 (1907), No. 534.

[3] Hall, Jour. Roy. Agr. Soc., 70 (1909), p. 12.

[4] Hunt, Bul. 90, Penn. State Exp. Sta.

125 pounds of potash. The only organic matter added has been in the form of crop residues and catch crops plowed under. Hydrated lime was applied to one-half of the field at the rate of 3,000 pounds per acre in 1909, and again in 1913, when the rate of application was 4,000 pounds. The application was made crosswise of the plots so that every plot was half limed and half unlimed.

The first soil samples were taken from these plots in 1912, just before the fertilizers were applied and after the land had been plowed. The second set of samples was taken in the spring of 1913, immediately after the lime had been applied and harrowed in, but before the application of any fertilizers. The soils were taken to the laboratory as soon as sampled, thoroughly mixed and air-dried. In subsampling, the soil was passed through a sieve having seven holes to the linear inch. No finer sieve was used, as it was desired to have the soil in as nearly actual field condition as possible.

The crops grown in the years previous to the sampling (1911 and 1912) were corn with clover sown in the corn during the fall. The crops were the same both years, as the clover made a poor catch in 1911 and was plowed under.

Method of Investigation.

A large part of the investigation was carried on with different strengths of ammonium-sulfate solutions. The four strengths used most were one-tenth normal (N/10), normal (N), two and one-half times normal (2½ N) and five times normal (5 N).

Unless otherwise stated the soil was treated as follows: 150 grams of air-dried soil were treated with 750 cubic centimeters of the ammonium-sulfate solution. The mixture was allowed to stand, with frequent shakings, for two hours, and then filtered through an unwashed filter paper. In every case the filtrate was perfectly clear but yellow, the intensity of the color varying between the limed and unlimed soils and with the strength of the solution used. The solutions were all neutral to litmus and phenolphthalein.

The solutions were analyzed for the amount of ammonia absorbed, and for the iron and aluminium, calcium, sodium, potassium, sulfates, chlorides and nitrates removed.

Absorption of Ammonia.

The ammonia was determined by the magnesium oxide method.[1] From 1 to 10 cubic centimeters of the solutions were used for a determination, depending on the concentration of the solution. Table II. gives the amounts in milligrams of the ammonia absorbed by 100 grams of air-dried soil.

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[1] Bul. 107, Bureau of Chem., p. 9, 1910 edition.

TABLE II. — *Milligrams of Ammonia absorbed from Ammonium-sulfate Solutions by 100 Grams of Air-dried Soil.*

[0 L = plot 0, limed end; 0 UL = plot 0, unlimed end, etc.]

PLOT.	N/10 Solution.	N Solution.	2½ N Solution.
0 L,	72.5	212.5	–
0 UL,	60.0	162.5	175
1 L,	72.5	162.5	250
1 UL,	60.0	200.0	275
6 L,	77.5	187.5	175
6 UL,	42.5	62.5	100
7 L,	62.5	200.0	100
7 UL,	57.5	125.0	225
8 L,	67.5	150.0	150
8 UL,	42.5	87.5	235

Taking the plots as a whole we find that with an increase in the concentration of the ammonium-sulfate solution used the amount of absorbed ammonia increases. Comparing the amounts of ammonia absorbed by soil from the different plots we find that the unlimed ends of plots 6 and 8 consistently show a smaller absorption than any of the others, except in one case with the strongest solution by soil from plot 8. The variations in amounts absorbed on the remaining plots are within the limits of possible error, on account of the concentration of the solutions employed.

ABSORPTION OF DYES.

This difference in the absorption capacity of the different plots is less strikingly shown by a study of the dye absorption. The dyes used were aniline blue, aniline green, corraline and eosine. The method of procedure was as follows: 10 grams of soil were shaken up with 100 cubic centimeters of the dye and then set aside until the supernatant liquid was clear. Fifty cubic centimeters were then pipetted off and compared with a standard dye solution in a colorimeter.

The eosine and corraline were not absorbed by the soil in a measurable quantity, if at all. One hundred cubic centimeters of the aniline blue and aniline green in concentrations below 50 parts per million were entirely decolorized by 10 grams of soil. The concentrations used were 50 and 100 parts per million.

TABLE III. — *Dye absorbed by 10 Grams of Soil from 100 Cubic Centimeters of Dye Solution.*

PLOT.	Aniline Blue (50 Parts per Million).	Aniline Blue (100 Parts per Million).	Aniline Green (100 Parts per Million).
0 L,	49.68	98.45	97.00
0 UL,	49.71	98.50	95.00
1 L,	–	99.12	96.67
1 UL,	49.76	98.94	95.97
6 L,	49.73	98.58	95.30
6 UL,	49.33	93.54	87.50
7 L,	49.74	98.40	96.00
7 UL,	49.69	98.24	94.75
8 L,	49.73	98.61	94.50
8 UL,	–	97.76	92.00

The table shows that the unlimed ends of plots 6 and 8 absorb a little less dye than do the limed ends or the other unlimed ends. While the other plots also show a higher absorption in the limed than in the unlimed ends the differences are smaller.

The dyes seem to have a deflocculating effect on the clay in the soil, as they settle much more slowly than with a corresponding water treatment. This is particularly noticeable on the limed end of plot 1, from which the solution, even at the end of twenty-four hours, was too turbid to be used in a colorimeter.

CALCIUM OXIDE REMOVED.

Calcium oxide was determined by the titration method with potassium permanganate. The amounts removed from 100 grams of air-dried soil are shown in Table IV.

TABLE IV. — *Milligrams of Calcium Oxide removed from 100 Grams Air-dried Soil by Distilled Water and by Different Solutions of Ammonium Sulfate.*

PLOT.	1912.				1913.			
	Water.	N Solution.	2½ N Solution.	5 N Solution.	Water.	N/10 Solution.	N Solution.	2½ N Solution.
0 L,	–	–	–	–	12.26	103.75	218.05	257.30
0 UL,	–	–	–	–	7.04	61.98	108.45	116.55
1 L,	69.45	176.05	182.65	171.00	10.95	95.65	205.15	242.85
1 UL,	6.66	106.95	117.80	124.60	6.91	61.30	116.65	120.60
6 L,	12.73	116.75	118.05	105.50	11.21	82.19	156.65	184.90
6 UL,	8.42	36.47	42.08	53.90	7.82	18.19	27.11	25.26
7 L,	10.17	177.05	178.70	175.50	10.43	99.03	205.17	243.87
7 UL,	8.42	78.20	83.90	77.50	6.78	43.12	70.25	71.41
8 L,	11.92	122.05	131.10	106.50	9.91	92.95	199.05	233.66
8 UL,	8.77	58.20	59.60	65.85	8.21	37.05	60.10	60.63

Considering the table as a whole we find that more calcium is removed from the limed ends than from the unlimed. The effect of the application of lime in 1913 is plainly shown by the increased amount of calcium removed from the limed ends in 1913 over 1912 by the normal and 2½ normal solutions. Further, in 1912 no increase is noted in the amount of calcium removed from the limed plots with an increase in the concentration of ammonium-sulfate solution used. In 1913, however, an increase is noticed with each increase in the concentration of the ammonium-sulfate solution. With the unlimed ends of the plots no such increase is noticed either year, except between the one-tenth normal and normal concentrations.

Studying the variations between the different plots we find the chief difference to be the smaller amount of calcium removed from the two sulfate plots 6 and 8, both limed and unlimed ends.

In the light of results already reported by other investigators as to the action of ammonium sulfate on calcium in the soils, the foregoing results indicate that ammonia replaces calcium in the soil, the amount varying with the concentration of the ammonium sulfate used and the amount of available calcium in the soil. The smaller amount of calcium removed from the two ammonium-sulfate plots indicates that the previous fertilization with ammonium sulfate has depleted the soil of this element. That sodium nitrate has had a protective action on the calcium in the soil is shown by the larger amount of calcium removed from the unlimed end of the nitrate plot 1 than from the no-nitrogen plot 7. The presence of the soda has prevented the soil from becoming poor in calcium. When larger quantities of lime are present, and the concentration of the ammonium-sulfate solution is high, the protective action largely disappears, as is shown by the amount of calcium removed from the limed end of plot 1 in comparison with plot 7.

Sodium and Potassium removed.

Owing to the large mass of ammonium sulfate and the small amount of sodium and potassium in solution it was difficult to make exact determinations of these elements. Several methods were studied, but the method of weighing the sodium and potassium as the double chlorides, and then determining the potassium as the chlorplatinate was finally adopted. The results obtained are as accurate as could be expected under the circumstances.

TABLE V. — *Milligrams of Sodium Oxide removed from 100 Grams of Air-dried Soil by Different Solutions of Ammonium Sulfate.*

PLOT.	N/10 Solution.	N Solution.	2½ N Solution.
0 L,	13.25	32.60	-
0 UL,	11.40	20.40	25.45
1 L,	14.05	-	23.05
1 UL,	13.50	20.40	22.55
6 L,	7.95	17.75	21.20
6 UL,	9.80	-	18.85
7 L,	9.55	19.90	22.00
7 UL,	10.10	18.30	24.40
8 L,	8.75	19.90	22.00
8 UL,	8.20	-	18.75

Milligrams of Potassium Oxide removed from 100 Grams of Air-dried Soil.

0 L,	12.00	13.60	-
0 UL,	10.75	27.15	20.85
1 L,	15.45	-	27.15
1 UL,	10.75	23.70	23.05
6 L,	10.00	21.50	24.95
6 UL,	12.65	-	21.50
7 L,	17.70	31.25	28.75
7 UL,	13.90	26.85	29.05
8 L,	14.55	26.20	25.25
8 UL,	11.70	-	22.75

As with the calcium the sodium and potassium removed increase with the concentration of the ammonium-sulfate solutions used. Unlike the calcium there are no marked differences in the amounts removed from the limed and unlimed ends of the plots, or from the different plots. This would seem to indicate that the continued use of ammonium sulfate has not diminished the amount of sodium and potassium in the soils, or, stated differently, the absence of lime has not increased the rate at which they were removed from the soils.

In determining the acids in the ammonium-sulfate solutions, the large amounts of ammonium sulfate presented difficulties which interfered with the accuracy of the determinations in every instance.

Sulfuric Acid removed.

In determining the sulfates the small aliquot which had to be taken owing to the amount of sulfates present made a slight error in weighing assume large proportions when figured to sulfates removed from 100 grams of soil. This was especially true of the 2½ normal and 5 normal extracts. In almost every case, however, more sulfates were found in the extracts than were present in the original solutions used. Where this was not the case the difference between the amount present in the original solution and the amount found in the extract was so small as to come easily within the limit of error. The results indicated that there was no accumulation of sulfuric acid in the soil which would cause it to become acid.

Hydrochloric Acid removed.

In trying to determine the amounts of hydrochloric acid in the extract by titration it was found that the ammonium sulfate prevented the development of the color. In making gravimetric determinations no precipitate or cloudiness was observed using 100 cubic centimeter aliquots. This shows that the chlorides if present at all were present in concentrations of less than one part per million of extract, or less than one-tenth of a milligram removed from 100 grams of soil.

Nitric Acid removed.

Nitric acid could not be determined with any degree of accuracy by the colorimetric method. The few determinations made on the more dilute extracts indicated that there was no appreciable difference in amount removed between the different plots. The average amount found was 1.5 parts per hundred thousand.

Iron and Aluminium removed.

The iron determinations could be made colorimetrically only after the largest part of the ammonium sulfate had been removed, as it prevented the development of the color with the thiocyanate. No colorimetric determinations were made on the 2½ normal and 5 normal extracts, as the amount of ammonium sulfate was too large to be driven off by ignition without some mechanical loss.

In the 2½ normal and 5 normal concentrations of ammonium-sulfate extracts, iron and aluminium were determined together by precipitating with ammonia as the hydrate. The precipitates were all light in color, showing that they were mostly aluminium, but all had some iron present.

No iron was found in the extracts from the limed ends of the plots with any of the ammonium-sulfate solutions, except on plot 6 with the 2½ normal solution, and on all the plots with the 5 normal solution. In all the extracts from the unlimed ends of the plots iron was found in varying amounts. A slight increase in the amount removed, with an increase in the concentration of the ammonium-sulfate solution used, was noticed. The largest amount was removed from one of the ammonium-sulfate plots, — No. 8.

TABLE VI. — *Milligrams of Iron Oxide removed from 100 Grams of Air-dried Soil by Different Solutions of Ammonium Sulfate.*

PLOT.	N/10 Solution.	N Solution.
1 UL,	.40	.79
6 UL,	.46	.51
7 UL,	.43	.50
8 UL,	.89	1.02

TABLE VII. — *Milligrams of Iron and Aluminium Oxides removed from 100 Grams of Air-dried Soil by Different Solutions of Ammonium Sulfate.*

PLOT.	N Solution.	2½ N Solution.	5 N Solution.
1 UL,	None.	4.25	6.50
6 UL,	12.00	12.00	33.00
7 UL,	2.00	8.00	7.50
8 UL,	1.50	7.75	28.00
6 L,	None.	2.50	8.00

The most striking difference is in the much larger amount removed from the ammonium-sulfate plot 6 UL.

In trying to purify the precipitates it was found that they contained silica as well as the oxides of iron and alumina.

In order to determine if these precipitates had the same composition in all cases, or varied with the concentration of the solvent used, extracts with different strengths of ammonium-sulfate solutions were made with soil from the unlimed end of plot 6. One-tenth normal, one-half normal and normal concentrations of ammonium-sulfate solutions were employed and the extracts made in the usual way. On addition of ammonium hydrate to the extracts a flocculent precipitate formed, which, after being dried and ignited, proved to have the following approximate composition: —

	Per Cent.
Oxides of iron and aluminium,	75
Silica,	25

The precipitates from the different strengths of ammonium-sulfate solution all had about the same composition. Attempts made to obtain this compound in water extracts were successful when a smaller ratio of soil to water was used and the two left in contact a greater length of time. Soils from the unlimed ends of plots 6 and 8 were used. The extracts were obtained as follows: between 6 and 8 kilos of air-dried soil were placed in a glass jar with an opening in the bottom plugged with glass wool and covered with a linen filter. Enough water was added to just saturate the soil and left for from twelve to twenty-four hours. In the first experiment only as much water was percolated through the soil as was required originally to saturate it. After evaporating the percolate to a small volume, and making slightly acid with hydrochloric acid to decompose any carbonates present, ammonium hydrate was added until the solution was slightly alkaline. A heavy flocculent precipitate, brick red in color, separated out. On filtering, drying and analyzing the precipitate it was found to contain organic matter, calcium, iron and aluminium and silica. The composition of this precipitate varied somewhat from the compound obtained with the ammonium-sulfate solutions. In the ammonium-sulfate extracts the amount of iron and aluminium oxides was about three times the amount of silica found, while with water the percentage of iron and aluminium oxides was almost the same as the per cent. of silica. In the extract made in a similar manner with soil from the unlimed end of plot 8 a precipitate similar in appearance but of a somewhat different composition was found. More silica than iron and aluminium oxides was found.

The increased amount of iron and aluminium found in the extracts with ammonium sulfate over that found in water extracts seems to indicate that in the absence of an available calcium compound the ammonium sulfate attacks the iron and aluminium compounds in the soil.

Investigations in regard to this solvent action of ammonium sulfate on iron and aluminium compounds in the soil are at present being conducted.

Calcium Absorption.

The absorption of calcium by the soil was studied in connection with the determination of soil acidity by the Veitch method. This method is essentially a measure of the absorption of lime by the soil and not a measure of any free acid.

The Veitch method was used on soil from the unlimed and limed ends of plot 6. No difference in the amount of absorbed calcium was noted between the limed and unlimed areas, both having absorbed at the rate of 2,545 pounds of calcium oxide per acre (2,000,000 pounds of soil per acre).

A second method, using the same substance, was also tried. In this method 100 grams of air-dried soil were shaken with 500 cubic centimeters of a saturated calcium-hydrate solution and filtered after two hours. An aliquot of the filtrate was then titrated and the amount of absorbed lime determined. This method gave a much higher absorption than was found by the Veitch method. No difference in the amount of calcium absorbed between the limed and unlimed ends was observed. The calcium oxide absorbed was equal to 11,776 pounds per acre.

A third method, taking a solution of calcium sucrate, was also used. Ten grams of soil were shaken with 50 cubic centimeters of the solution, filtered after two hours and an aliquot titrated. Two strengths of the calcium-sucrate solution were used, — a saturated solution and another one-tenth as strong. The absorption of calcium was the same with both solutions and on both the limed and unlimed areas. The absorption was much greater than with either of the two previously mentioned methods. The unlimed end absorbed at the rate of 26,660 pounds of calcium oxide per acre, while the limed end absorbed at the rate of 23,850 pounds per acre. The greater absorption of the calcium from the sucrate solutions is due to the greater concentration of calcium in these solutions. The Veitch method does not measure the true absorptive capacity of the soil, but measures the absorption up to the point of alkalinity of the soil. That the soil can absorb more calcium after the point of alkalinity is reached is shown by the results obtained by the other methods. With the calcium-sucrate solution the limit of the amount of calcium which the soil can absorb seems to have been reached, as with an increase in the concentration no increase in the amount of calcium absorbed is noted.

It is of interest to compare the results obtained by the above methods with the calcium oxide equivalent obtained with the Hopkins method of determining soil acidity. With this method a marked difference between the limed and unlimed areas of plot 6 is found. The unlimed area has a much higher calcium oxide equivalent than the limed area. The calcium oxide equivalent of the limed end is 631 pounds of calcium oxide per acre, while the unlimed gives an equivalent of 4,976 pounds per acre.

This "acidity," however, is not due to the presence of free acids, either soluble or insoluble in water, but is probably due to the presence of iron and aluminium salts. When the soils are shaken up with the normal potassium-nitrate solution, as the method calls for, an action resembling a double decomposition takes place between the iron and aluminium compounds and the potassium nitrate, with the formation of the easily hydrolyzable iron and aluminium nitrates which go into solution. When the aliquot is titrated the titration shows the amount of nitric acid present in combination with iron and aluminium, as is evidenced by the heavy flocculent precipitate which forms during the titration. In order to determine if nitrates of iron and aluminium hydrolyze readily, known solutions of those salts were made up and titrated. It was found that the entire quantity of nitric acid present could be titrated.

Summarizing the results obtained by the different methods, we find that the soil absorbs increasing amounts of calcium from increasing concentrations of calcium solutions, and that the limed and unlimed plots absorb practically like amounts of actual calcium.

Analysis of Drainage Waters.

To determine if the composition of the drainage waters would throw any light on the effect of long-continued use of ammonium sulfate as a fertilizer, the following analyses of drainage waters from the plots studied in the first part of this bulletin were undertaken.

The drainage waters were collected in the spring and fall of 1912 and 1913. Most of the samples were collected in the spring after the frost had left the ground. Only three samples were taken in the late fall. No drainage took place during the summer and early fall. The waters at all times were clear and free from sediment of any kind. In the spring of 1912 five sets of samples were collected, — the first on March 18 and the last on May 17. In the fall a set of samples was collected on November 5 and December 6. In 1913 the first samples were taken on March 9. Five subsequent sets of samples were taken at intervals of one week. Another set was obtained on December 8.

The waters were analyzed for total solids, fixed solids, calcium, sodium, potassium, iron, chlorides and sulfates. As the nitrates vary between wide limits within short spaces of time no attempts were made to determine them, except when the water could be analyzed as soon as collected. Iron was found in traces only in any of the waters.

The amount of drainage varied considerably between the different plots. The amount can be estimated only by the apparent flow from the outlets. Plot 0 had the largest amount, with plots 1 and 7 closely following in the order named. Plots 6 and 8 had the smallest amount. The differences can be explained in part by the general slope of the field. Plots 0 and 1 are the lowest in the field. While the slope is not great it is probably enough to cause some increase on the lower plots. The actual amount of drainage for the year could not be determined, as means for measuring the flow were not available.

Table VIII. — *Average Composition of Drainage Waters in Parts per 100,000.*

1912.

Plot.	Total Solids.		Loss on Ignition.		Calcium Oxide.		Sulfur Trioxide.		Chlorine.	
	Spring.	Fall.	Spring.	Fall.	Spring.	Fall.	Spring.	Fall.	Spring.	Fall.
0, ...	16.86	17.95	5.0	6.6	2.06	4.25	5.36	6.07	1.42	1.66
1, ...	24.60	27.60	7.2	7.9	2.43	4.30	8.16	7.87	3.05	4.27
6, ...	27.60	35.50	5.7	8.9	4.39	11.85	11.61	13.29	2.81	3.99
7, ...	21.30	23.40	7.0	6.9	2.49	7.20	8.72	8.17	2.15	3.58
8, ...	30.30	32.90	7.5	7.8	4.82	10.45	12.95	12.79	2.55	3.15

TABLE VIII. — *Average Composition of Drainage Waters in Parts per 100,000* — Concluded.

1913.

Plot.	Total Solids.		Loss on Ignition.		Calcium Oxide.		Sodium and Potassium Chlorides.	Sulfur Trioxide.		Chlorine.	
	Spring.	Fall.	Spring.	Fall.	Spring.	Fall.	Spring.	Spring.	Fall.	Spring.	Fall.
0, . .	17.9	22.6	3.78	6.4	4.05	4.51	5.0	6.92	7.67	1.26	1.45
1, . .	22.7	27.5	3.50	5.0	3.82	3.99	10.2	6.86	7.61	3.19	4.97
6, . .	24.0	33.1	5.46	6.3	6.71	8.30	4.6	8.88	11.13	2.79	4.83
7, . .	20.2	26.9	4.72	6.0	5.24	6.73	4.9	6.49	6.65	2.72	5.62
8, . .	26.4	36.8	5.28	6.5	8.03	9.67	5.2	9.79	11.70	2.88	5.35

Comparing the results plot by plot the first difference noted is in the amount of total solids removed. More soluble salts are removed from the two sulfate plots 6 and 8 than from any of the others. The same is true of the calcium removed, the ammonium sulfate evidently reacting with the calcium in the soil to form calcium sulfate. This is borne out by the increase in the amount of sulfates removed from these two plots. These results are similar to those obtained by Lawes and Gilbert at Rothamstead, in their study of the drainage waters from ammonium-sulfate-treated plots in comparison with those differently fertilized. The protective action of sodium nitrate for calcium is again shown, as the amount of calcium removed from the nitrate plot 1 is smaller than that removed from the other plots. The increase in the amount of sodium and potassium chlorides removed from this plot is due to the sodium nitrate. While the above table would lead one to think that the drainage waters from the different plots had a radically different composition from one another, this is not true, as a study of the average percentage composition of the fixed solids will show.

TABLE IX. — *Average Percentage Composition of Fixed Solids.*

1913.

Plot.	Calcium Oxide.		Sulfur Trioxide.		Chlorine.	
	Spring.	Fall.	Spring.	Fall.	Spring.	Fall.
0,	28	28	48	47	9	9
1,	21	18	40	34	19	22
6,	36	31	48	42	15	18
7,	33	32	42	32	18	27
8,	36	32	47	38	14	11

While the waters differ somewhat in their composition, the main difference between them is in the concentration. The waters from the sulfate plots are more concentrated than the others.

The theory that calcium, when removed from the soil through fertilization with ammonium sulfate, is removed in the form of calcium sulfate is borne out by the above results. This is more clearly shown by the ratio of calcium oxide to sulfur trioxide, which is fairly constant for the plots.

As the waters from the limed and unlimed parts of the plots cannot be kept separate, the differences due to liming one-half of each plot cannot be determined. To determine if possible whether any differences existed, the following experiment was conducted with soil from the limed and unlimed areas of plots 5 and 6.

Galvanized-iron cylinders 3 inches in diameter were driven into the soil to a depth of 8 inches, and a column of soil thus removed. The soil was left in the cylinder just as it was removed and taken to the laboratory. A linen cloth filter was then placed over the bottom of the cylinder and the soil saturated with distilled water. When saturated, 500 cubic centimeters of distilled water were poured on top and allowed to percolate through. This was repeated five times, making six percolates from each sample. Three samples from each plot were treated in this way.

For purpose of analysis the second to the sixth percolates, inclusive, were combined into one sample. The solutions were then analyzed for total and fixed solids, calcium, sodium, potassium, magnesium, iron, aluminium, sulfates and chlorides.

TABLE X. — *Composition of Percolates in Parts per 100,000.*

	PLOT 5 L.		PLOT 5 UL.		PLOT 6 L.		PLOT 6 UL.	
	First.	Combined.	First.	Combined.	First.	Combined.	First.	Combined.
Total solids,	83.10	23.20	79.30	27.50	89.90	24.50	112.30	29.70
Fixed solids,	67.30	18.60	66.40	23.50	72.20	19.70	97.30	24.00
Calcium oxide,	22.45	5.68	17.43	4.92	23.75	6.65	25.53	6.44
Potassium oxide,	.85	.44	3.16	1.80	1.03	.50	3.57	2.36
Magnesium oxide,	1.78	1.11	1.99	.65	.77	.35	1.13	-
Sulfur trioxide,	41.60	10.53	40.09	13.50	28.71	9.59	30.77	13.82
Chlorine,	1.26	.17	.80	.20	10.38	.49	22.45	2.89

TABLE XI. — *Percentage Composition of Fixed Solids.*

	PLOT 5 L.		PLOT 5 UL.		PLOT 6 L.		PLOT 6 UL.	
	First.	Combined.	First.	Combined.	First.	Combined.	First.	Combined.
Calcium oxide,	33.36	30.54	26.25	20.94	32.89	33.76	26.24	26.83
Potassium oxide,	1.26	2.37	4.76	7.66	1.43	2.53	3.67	9.83
Magnesium oxide,	2.64	5.97	2.99	2.76	1.07	1.78	1.16	-
Sulfur trioxide,	61.81	56.61	60.38	57.45	39.76	48.68	31.62	57.58
Chlorine,	1.87	.91	1.20	.85	14.38	2.48	23.07	12.04

The first difference noticed on studying Table X. is the larger amount of soluble salts removed in the first percolate than in the subsequent portions. That this difference is largely a matter of concentration is shown by a comparison of the constituents as shown in Table XI. The variations between the two plots are those due to the different fertilizers used. Plot 5 has more sulfates and magnesium and less chlorides removed than plot 6. Since plot 5 received its application of potash as low-grade sulfate and plot 6 as muriate of potash, these differences were to be expected.

The variations between the limed and unlimed ends of the plots are very similar. More calcium and less potash are removed from the limed ends than from the unlimed. Traces of iron and aluminium were found in all of the extracts, but showed no difference between the two plots or between the limed and unlimed areas of the plots.

Comparing the percentage composition of the percolates and the drainage waters, both based on the fixed solids, we find them agreeing very closely. The per cent. of calcium oxide in the drainage water of 1913 for plot 6 is 36 as against 30 found in the percolation waters from this plot, averaging the limed and unlimed. Sulfates in the drainage waters are 48 per cent. and in the percolates 44 per cent., and chlorides in the drainage waters are 15 per cent. and in the percolates 13 per cent. of the fixed solids. The higher results in the drainage waters are probably due to the fact that more of the drainage comes from the limed ends of the plots than from the unlimed.

Culture Studies.

The first culture work undertaken in connection with this problem was to determine if the infertility of the soils extended to their water extracts, as was found by Whitney,[1] Livingston[2] and others.

The seedlings used were rye, barley and red clover, which were germinated on paraffin-covered wire gauze as described in Bulletin No. 40, Bureau of Soils. When the stems of the seedlings reached a length of one inch they were transferred to notched corks and placed in the culture solutions.

The culture solutions were contained in salt-mouth bottles of 250 cubic centimeters' capacity, with necks having a diameter of 1¼ inches. Four seedlings were placed in each bottle. As each experiment was carried on in triplicate this gave a total of twelve seedlings for each treatment.

The soil extracts were made by mixing two parts water with one part soil and letting the mixture stand for about two hours with frequent shakings, when the water was either poured off or filtered through porcelain filters under pressure.

The first series was conducted with extracts from the limed and unlimed ends of plots 1, 6, 7 and 8. One set was made up with filtered extracts, and a second set with the unfiltered extract. The seedlings used were rye and red clover. The experiment was continued four weeks, at the end of which the plants began to wilt.

The first differences were noted at the end of the first week, the rye seedlings in the extracts from the limed ends of the plots being better than those in the extracts from the unlimed areas. The seedlings in the extracts from the unlimed areas all had a reddish-colored stem, and did not make as good a growth as the others. The clover seedlings showed similar differences, but more in the roots than in the tops. The differences became more marked as time went on, and differences in the root development became noticeable. The roots in the extracts from the unlimed end of plot 6 became stunted and thickened,[3] and the roots in the extract from the unlimed end of plot 8, while not stunted, showed a poorer growth than the others. When the experiment was discontinued the seedlings in the extracts from the limed end of plot 1 and plot 8 were the best, with the poorest in the extracts from the unlimed ends of plots 6 and 8. As the clover seedlings did not make much growth they were omitted in the second series and only barley was used. Barley was chosen, as it has been found to be more sensitive to toxic substances than rye seedlings. The filtered extracts were also omitted, as no difference was noticeable between the filtered and unfiltered extracts in the first series.

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[1] Bul. 23, Bureau of Soils, Whitney and Cameron.

[2] Bul. 28, Bureau of Soils, Livingston *et al.;* Bul. 36, Bureau of Soils, Livingston.

[3] Bul. 161 contains descriptions and photographs of clover roots similar to the roots of seedlings in these cultures.

As in the first series the second was continued four weeks. At the end of the first week no differences were noticeable in the tops, but the roots in the extract from the unlimed end of plot 6 again showed the stunted and thickened appearance. At the end of two weeks the tops in the extracts from the unlimed ends of the plots began to wilt, the tips of the leaves turning white. When the experiment was discontinued the seedlings in the extracts from the limed ends of the plots appeared just about alike, while in the extracts from the unlimed ends the poorest were the seedlings in the extract from plot 6. The seedlings were weighed green, but the weights did not show the differences which were apparent to the eye.

When iron and aluminium compounds were found in the soil it was thought that these might have a toxic influence on plants, so culture work was undertaken, using these salts. The results of this experiment have already been published.[1] It is only necessary to state that iron and aluminium salts are very toxic to clover seedlings, and that in dilute solutions calcium carbonate can overcome the toxicity.

Summary and Conclusions.

The results of the experiments show that —

(*a*) The absorption of ammonia from sulfate of ammonia solutions by the soils studied increases with the increase in the concentration of the ammonium-sulfate solution used. This increase is not strictly proportional to the increase in the concentration of the ammonium-sulfate solutions. The soils from two plots previously fertilized with ammonium sulfate without lime absorb less ammonia than do the other soils. This shows that the continued use of ammonium sulfate has caused some change in the soil.

(*b*) The absorption of dyes by these soils is very similar to the absorption of ammonia. More dye is absorbed from the more concentrated solution than from the lesser concentration. The two unlimed sulfate plots also absorb less than do the others, showing that their absorptive powers have been lessened.

(*c*) Ammonium sulfate has a solvent action on the calcium in the soils, and depletes the soil of this element. This is shown by the ammonium-sulfate extracts and also by the drainage water analyses.

(*d*) Ammonium sulfate seems to have no solvent action on sodium or potassium in the soil in the presence of sufficient quantities of lime. That it has a slight solvent action on potassium in the absence of lime is shown in the percolation experiment, where more is removed from the unlimed plots than from the limed. This may be more beneficial than harmful, as it will make more potash available for the use of plants.

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[1] Bul. 161, Mass. Exp. Sta., 2d part.

(*e*) The use of ammonium sulfate probably does not cause the accumulation of sulfates in the soil, as is indicated by the marked removal of sulfates from the sulfate plots in all of the experiments. All of the soil extracts were neutral to indicators, showing that no free soluble acids were present in the soil. The absence of free acids is further shown by the amounts of calcium absorbed. Using different calcium solutions, no difference in the amount of calcium absorbed is found between the limed and unlimed ends. If a free acid or acids were present in the soil from the unlimed areas, these soils should have absorbed a greater amount of lime than the soils from the limed areas of the plots.

Whether the action of the ammonium sulfate in the soil is one of double decomposition between the ammonium sulfate and calcium carbonate, or in its absence some other salts, or whether the ammonia is first absorbed physically, and the sulfuric acid thus set free reacts with the calcium, is still a matter of dispute. While the results obtained do not prove either of these theories to be correct, they seem to indicate that it may be a combination of these two that takes place.

The similarity between the absorption of ammonia and the absorption of dyes is evidence that the ammonia is held by physical rather than chemical forces. That it is not purely a chemical exchange is shown by the increased amounts absorbed with the increased concentrations of the solutions used, and, as Voelcker and others have shown, all of the ammonia is never absorbed from a solution, no matter how dilute. That some chemical reaction takes place is shown by the amounts of calcium removed. The amounts removed reach a definite limit, above which none is removed, when the soil is shaken with a normal ammonium-sulfate solution.

What takes place in soil fertilized with ammonium sulfate may be as follows: the first reaction to take place is the physical absorption of the ammonia, thus setting free sulfuric acid. If, after the soil has absorbed all the ammonia it is capable of holding, some ammonium sulfate remains, double decomposition takes place. In both cases the first salt to be attacked is probably the calcium carbonate, and it is only in the absence of this salt that the iron and aluminium compounds are attacked. It is to these salts of iron and aluminium that the infertility of the plots continuously fertilized with sulfate of ammonia appears to be due.

IMPROVED METHODS FOR FAT ANALYSIS.

E. B. HOLLAND, J. C. REED AND J. P. BUCKLEY.[1]

INTRODUCTION.

Experiments in animal nutrition have constituted a prominent line of investigation at the Massachusetts Agricultural Experiment Station ever since its organization, and numerous attempts have been made to determine the effect of feed on the composition of the resulting butter fat.[2] These experiments extended over a number of years and required the analysis of many samples of fat. A careful study of the technique of fat analysis, in so far as the more common group methods are concerned, was undertaken at the outset and has been continued to the present time. With increasing experience, plans were formulated for a systematic correlation and standardization of the various processes, and considerable progress has been made in that direction. The object was to promote accuracy by greater uniformity and simplicity of methods, embracing definition of terms, principles involved and details of manipulation, including reagents, apparatus and glassware. A report on "Methods for Fat Analysis"[3] was published some years ago.

Innumerable modifications suggested by foreign and American investigators in addition to those resulting from our own initiative have necessitated a complete revision of former methods. While these in turn will be superseded in the light of subsequent progress, they are offered in the hope that they may prove of service to fellow workers in oils and fats.

At the outset oils, fats and waxes are defined, classified, and a synopsis of composition given in order that the value of the data contributed by the various determinations whereby the "structural" composition of the product is evolved may be fully understood. The organoleptic tests are merely enumerated, as their application is self-evident. They are employed in classification, are very serviceable in identification, and particularly valuable in discriminating as to quality or grade, for which experience and general knowledge of the trade are essential.

The more prominent physical tests are of such a well-known character that time is not taken to consider their special modifications. They furnish a certain amount of confirmatory evidence, and are occasionally employed for "culling" suspicious samples. With lubricating and illuminating (hydrocarbon) oils they are far more important. The chemical methods are indispensable for determining the identity, composition and quality of oils and fats, and are treated in a monographical way.

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[1] Mr. Reed was associated in the earlier and Mr. Buckley in the later stages of the work.

[2] Rpts. Hatch Expt. Sta., 13, pp. 14–33 (1901); 14, pp. 162–168 (1902); 16, pp. 45–62 (1904). Mass. Agr. Expt. Sta. Rpt. 21, Pt. 2, pp. 66–110 (1909).

[3] Rpts. Mass. Agr. Expt. Sta., 21, Pt. 2, pp. 120–138 (1909); 22, Pt. 1, p. 139 (1910).

In standardizing the methods an effort was made to use not only the same flasks but also the same amount of material, volume of solution and indicator, and the same agent to facilitate boiling and like conditions of treatment in so far as possible. All the methods, practically without exception, have been modified in reagents and manipulation, and attention called to numerous precautions found necessary for accurate work. This is especially noticeable in the determination of insoluble acids, unsaponifiable matter and iodine number. The determination of acetyl number should be considered a new method. The process for determining stearic acid is a modification of the Hehner and Mitchell method adapted for use with the insoluble acids of butter fat for which the original did not prove applicable. The limits of error are original, based chiefly on practical manipulation, although considered on theoretical grounds. The synopsis of reaction expresses the successive steps and underlying principle in each process free from verbiage. The supplementary notes include any information, original or otherwise, that might be of service in interpreting results. All tables and formulas are calculated on the latest atomic weights, and many formulas express old principles in a new light.

This article constitutes a portion of a paper submitted for the degree of doctor of philosophy at the Massachusetts Agricultural College.

Classification — Oils, Fats and Waxes.

Natural oils may be divided into two major groups, *i.e.*, essential, ethereal or volatile oils, and fatty, fixed or nonvolatile oils.

The fatty oils may be subdivided according to consistency at ordinary temperature into oils and fats; according to origin, into vegetable and animal; according to properties, into drying, semidrying and nondrying, etc.

Waxes are generally grouped with the fatty oils on account of their similar chemical structure. Oils and fats are essentially neutral glyceryl esters, compounds of fatty acids and the soluble tribasic alcohol, glycerol. Waxes are composed of esters of fatty acids and insoluble monobasic and occasionally dibasic alcohols, together with a considerable proportion of free alcohols and of hydrocarbons.

Any general classification of oils, fats and waxes, whether of origin, of physical characteristics, or of chemical characteristics, is open to criticism; probably that of Lewkowitsch, based on the magnitude of the iodine number correlated with that of consistency, origin and properties, is the best that has been offered.

Oils, Fats and Waxes.

Oils	Vegetable oils	Drying oils	
		Semidrying oils	Cottonseed oil group Unnamed group Rape oil group
		Nondrying oils	Unnamed group Castor oil group
	Animal oils	Marine animal oils	Fish oils Liver oils Blubber oils
		Terrestrial animal oils	
Fats	Vegetable fats		Chaulmoogra oil group Laurel oil group Palm oil group Myristica group Cacao butter group Coconut oil group Dika fat group Unnamed group
	Animal fats	Body fats Drying fats Semidrying fats Nondrying fats Milk fats	
Waxes	Liquid waxes	Animal waxes	
	Solid waxes	Vegetable waxes Animal waxes	

ORGANOLEPTIC TESTS.

Consistency (20° C.), ...	Liquid. Semifluid. Solid.
Turbidity, ...	Water or other nonmiscible substances.
Sediment, ...	Stearin, tissue, dirt, etc.
Color[1] (0.5 inch cell), ...	Water white (colorless). Straw color. Lemon yellow. Bright yellow (most oils when refined). Dirty yellow (beeswax). Bright red. Dirty dark red (crude palm oil). Yellowish green (laurel oil). Green (chlorophyll). Brown. Black.

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[1] Arbitrary commercial terms are often employed in designating oils. A scientific color standard of the Milton Bradley Company's type appears impractical, but Lovibond's tintometer promises more satisfactory results.

Transparency or opacity (0.5 inch cell).	
Fluorescence or bloom,	Mineral oils, seldom in fatty oils.
Odor (cold and hot),	Characteristic of product (fatty acids, amines, etc.).[1] Rancidity.
Taste,	Characteristic of product. Finest (first quality), "hard," "harsh." Rancidity.

PHYSICAL TESTS.

Specific gravity,	$d\frac{t}{4^\circ C.}$ $t = 20^\circ, 40^\circ$ and 60° C. Coefficient of expansion.
Melting point,	° C. (lower in mixed than in simple glycerides).
Solidifying point,	° C.
Refractive index,	Abbe refractometer, $n\frac{t}{D}$ $t = 20^\circ, 40^\circ$ and 60° C. Dispersion.
Optical rotation,	Dextro rotatory, 200 m.m. tube. Lævo rotatory.
Colorimeter,	Lovibond tintometer, 0.5 inch cell.
Viscosity,	Redwood viscosimeter, 70° Fahr.
Solubility,	Crismer, critical temperature of dissolution, ° C. Valenta test, ° C.
Flash point,	° C.
Ignition point,	° C.

SYNOPSIS OF COMPOSITION — OILS AND FATS.

Neutral fat (glycerides)	Fatty acids Glycerol
Free fatty acids	
Unsaponifiable matter[2]	Sterols[3] Hydrocarbons Chromogenic bodies, resinous substances, etc.

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[1] The odor of fish oils is said to be due largely to clupanodonic and homologous acids.

[2] Nominally a part of the neutral fat, but differentiated to facilitate subsequent calculations.

[3] Occur as free alcohols and, to some extent, in combination with fatty acids, as esters.

Fatty Acids and Glycerides.

Total fatty acids.

Neutralization number Mean molecular weight	
Fatty acids of neutral fat Neutralization number Mean molecular weight	Glycerides (neutral fat) Saponification number Mean molecular weight
Glycerol	
Free fatty acids Neutralization number Mean molecular weight	
Soluble fatty acids[1] Neutralization number Mean molecular weight	Glycerides Saponification number Mean molecular weight
Acetic acid	Acetin
Butyric acid	Butyrin
Valeric acid	Valerin
Caproic acid	Caproin
Caprylic acid	Caprylin
Capric acid	Caprin
Glycerol	
Volatile fatty acids[2] Neutralization number Mean molecular weight	Glycerides Saponification number Mean molecular weight
Glycerol	
Insoluble fatty acids[1] Neutralization number Mean molecular weight	Glycerides Saponification number Mean molecular weight
Lauric acid	Laurin
Myristic acid	Myristin
Palmitic acid	Palmitin
Stearic acid	Stearin
Arachic acid	Arachin
Oleic acid	Olein
Erucic acid	Erucin
Linolic acid	Linolin
Linolenic acid	Linolenin
Clupanodonic acid	Clupanodonin
Ricinoleic acid	Ricinolein
Dihydroxystearic acid	Dihydroxystearin
Glycerol	

SAPONIFICATION (KOETTSTORFER[3]) NUMBER.

The saponification number indicates the number of milligrams of potassium hydroxide required for the complete saponification of 1 gram of an oil, fat or wax.

Reagents. — Alcohol:[4] redistilled; free from acids and aldehydes.

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[1] The free soluble and insoluble acids should not be calculated to glycerides.

[2] Are considered as constituting a portion of the soluble acids.

[3] Ztschr. Analyt. Chem., 18, pp. 199–207, 431–437 (1879).

[4] To purify alcohol for use as a solvent or reagent in fat analysis, 5 gallons are treated with at least 10 grams of silver nitrate, thoroughly shaken, and allowed to stand to insure oxidation of aldehydes; then, with 1,000 grams of calcium oxide (caustic), repeatedly shaken for several days to remove acids and a portion of the water, filtered and redistilled. Fractionation is necessary if the boiling point exceeds a range of 1° C., the distillate should be preserved in glass and protected from sunlight.

Alcoholic potash solution:[1] 50 cubic centimeters of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of alcohol. The alkali should be added to the alcohol slowly with agitation in order to prevent any appreciable rise in temperature. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.

N/2 hydrochloric acid.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Cotton blue 6B[2] solution: 2 grams to 100 cubic centimeters of alcohol. The indicator should be boiled in a flask under a reflux condenser for two hours and then filtered.

Method. — Into a 300 cubic centimeter Erlenmeyer flask are brought 5 grams of fat (care being taken to avoid getting any fat on the sides of the flask), together with 50 cubic centimeters of alcoholic potash,[3] accurately measured with a burette, 50 cubic centimeters of alcohol and several glass beads. The flask is connected with a spiral or other form of reflux condenser and the solution boiled vigorously on a water bath (see Figs. 1 and 2) with occasional rotation until saponification is complete, — about

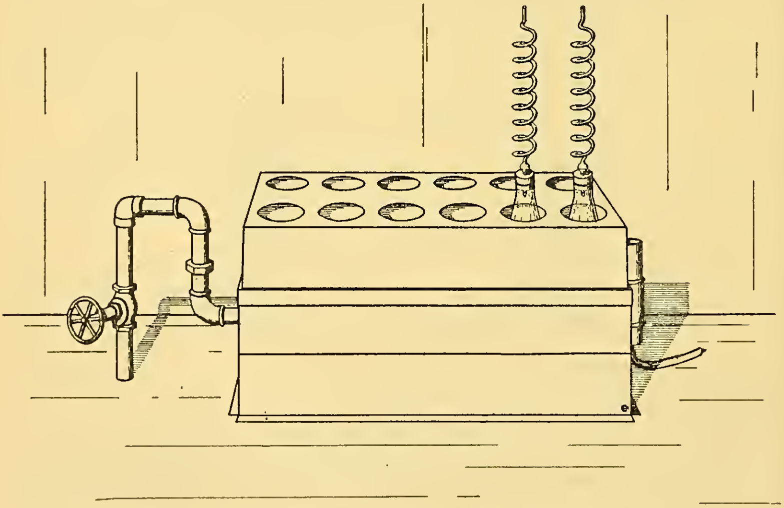

FIG. 1. — Steam-heated water bath employed in the determination of saponification, acid and acetyl numbers and insoluble acids.

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[1] Approximately 0.65 N solution. Alcoholic potash will dissolve about 0.04 gram of potassium carbonate to 100 cubic centimeters, according to Holde. — Chem. Rev. Fett u. Harz Indus., 14, pp. 105-107 (1907).

[2] Sodium salt of triphenylpararosaniline-trisulphonic acid. Obtained from National Aniline and Chemical Company, 100 William Street, New York, N. Y.

[3] For waxes, especially wool wax, potassium alcoholate is preferable on account of its greater efficiency. The solution should be freshly prepared by dissolving 5 grams of metallic potassium in 100 cubic centimeters of absolute alcohol. — Lewkowitsch, Analysis of Oils, Fats and Waxes, 1, p. 107 (1913).

sixty minutes. The reaction is quadrimolecular with triglycerides. The flask is then placed in a water bath at 60° C., and the solution, after cooling to that temperature, titrated with N/2 hydrochloric acid, using 1 cubic centimeter of phenolphthalein as indicator, to the complete elimination of the pink color. The cooling and dilution of the solution, due to the addition of the acid, occasionally give rise to small colored particles; this can be obviated by a slight increase in temperature. The end point is particularly difficult to determine in the presence of aldehydes, which impart a dark reddish-brown color to the solution. Fish oils behave in a like manner. In such cases cotton blue (1 cubic centimeter) is preferable to phenolphthalein. The change in color is from red with alkalies to blue with acids. The two indicators appear to give like results when considered in connection with their respective blanks. Absorption of carbonic acid from the air should be guarded against at all times. As alcoholic potash gradually loses alkalinity on boiling, the operation should be timed with reasonable care. Several blank determinations should be run with every series of tests under precisely similar conditions. The difference between the titration of the blank and that of the excess alkali in the test is the acid equivalent of the fat taken, which should be calculated to milligrams of potassium hydroxide for 1 gram of fat.

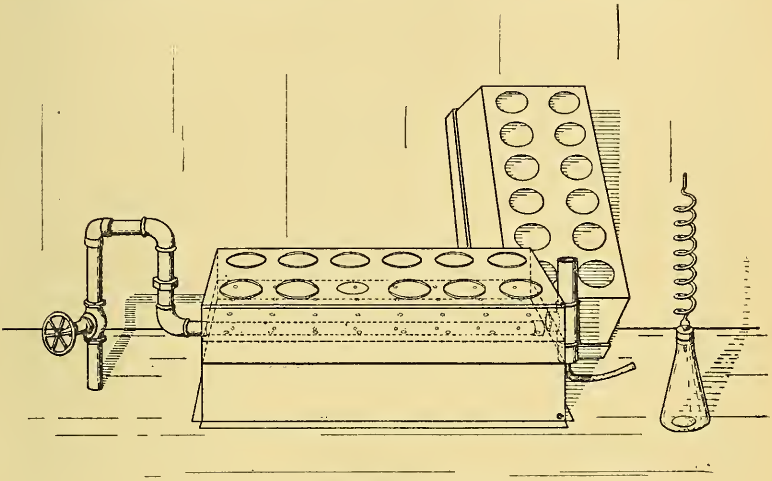

Fig. 2. — Detailed drawing of Fig. 1.

1 cubic centimeter of N/2 acid is equivalent to 28.054 milligrams of potassium hydroxide.

Limit of error, 0.50 milligram.

Synopsis of Reaction.

$$\underset{\text{fat}}{(RCOO)_3C_3H_5} + \underset{\text{alkali}}{3\,KOH} = \underset{\text{salt}^1}{3\,RCOOK} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

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[1] The term "soap" is now limited by custom to the alkali salts of insoluble fatty acids.

Titration of excess alkali.

R in the graphic formula of the fatty acids represents C and H in different amounts, according to the acid, but in the proportion of C_nH_{2n+1}, except in the case of unsaturated and of dibasic acids.

Saponification Numbers of Triglycerides.

GLYCERIDE.	Formula.	Molecular Weight.	Saponification Number.
Acetin,	$(CH_3COO)_3C_3H_5$	218.112	771.732
Butyrin,	$(C_3H_7COO)_3C_3H_5$	302.208	556.981
Valerin,	$(C_4H_9COO)_3C_3H_5$	344.256	488.950
Caproin,	$(C_5H_{11}COO)_3C_3H_5$	386.304	435.729
Caprylin,	$(C_7H_{15}COO)_3C_3H_5$	470.400	357.832
Caprin,	$(C_9H_{19}COO)_3C_3H_5$	554.496	303.562
Laurin,	$(C_{11}H_{23}COO)_3C_3H_5$	638.592	263.586
Myristin,	$(C_{13}H_{27}COO)_3C_3H_5$	722.688	232.914
Palmitin,	$(C_{15}H_{31}COO)_3C_3H_5$	806.784	208.636
Stearin,	$(C_{17}H_{35}COO)_3C_3H_5$	890.880	188.941
Arachin,	$(C_{19}H_{39}COO)_3C_3H_5$	974.976	172.644
Olein,	$(C_{17}H_{33}COO)_3C_3H_5$	884.832	190.233
Erucin,	$(C_{21}H_{41}COO)_3C_3H_5$	1,053.024	159.848
Linolin,	$(C_{17}H_{31}COO)_3C_3H_5$	878.784	191.542
Linolenin,	$(C_{17}H_{29}COO)_3C_3H_5$	872.736	192.869
Clupanodonin,	$(C_{17}H_{27}COO)_3C_3H_5$	866.688	194.215
Ricinolein,	$(C_{17}H_{32}.OH.COO)_3C_3H_5$	932.832	180.444
Dihydroxystearin,	$(C_{17}H_{33}(OH)_2COO)_3C_3H_5$	986.880	170.562

Supplementary Notes. — The term "saponification or saturation equivalent," as employed by Allen[1] and others, indicates the grams of fat that are saponifiable with one equivalent of potassium hydroxide in grams (56.108); in other words, the grams of fat saponifiable with 1 liter of N potassium hydroxide.

$$\text{Saponification equivalent (sq)} = \frac{56108}{s} \text{ or } \frac{\text{mg. of fat}}{\text{c.c. N alkali}};$$

$$\text{Saponification number (s)} = \frac{56108}{sq}.$$

The lower the molecular weight of the fatty acids (or esters) the more alkali will be required to satisfy 1 gram, and the higher will be the saponification number. The presence of free fatty acids increases the saponification number, and unsaponifiable matter decreases it. The majority of oils and fats have saponification numbers lying between 185 and 200, with a mean of approximately 193. While the numbers for different products are quite characteristic they are by no means fixed or constant, varying with the state of purity and rancidity. The character of an oil or fat is affected also by natural conditions, such as climate, soil, food supply and other factors influencing formation or production, and by method of separation or preparation.

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[1] Commercial Organic Analysis, 2, pp. 15, 16 (1910).

Fats and oils containing a considerable amount of the glycerides of the lower (volatile) fatty acids and of myristin are characterized by a saponification number exceeding 200. Among the more prominent of these, testing from 210 to 290, are croton oil, spindle tree oil, turtle, dolphin jaw, porpoise jaw and brown fish of the blubber oils, several of the myristica group, the coconut oil group including palm-nut, coconut and other less common oils, the dika fat group, Japan wax and butter fat. Oils and fats containing a considerable proportion of glycerides of the higher fatty acids, particularly hydroxy acids, are characterized by low saponification numbers. Castor oil, consisting largely of ricinolein, has a saponification number of about 185. The rape oil group, including rape (colza) and various mustard oils, have saponification numbers of about 175, on account of the large proportion of erucin.

Liquid and solid waxes, such as sperm oil, flax wax, wool wax, beeswax, spermaceti, insect wax, etc., are characterized by extremely low saponification numbers, from 80 to 140, due to the large proportion (nearly one-half) of monobasic alcohols and of hydrocarbons.

Monoglycerides, with only one acid radical, and diglycerides, with two, have a lower saponification number than the corresponding triglycerides with three acid radicals.

Glycerides can also be hydrolyzed by concentrated mineral acids; by superheated steam with a catalyzer such as hydrochloric acid or with an accelerator such as caustic lime, potash or other oxide; by enzymes; by sulfoaromatic compounds such as Twitchell reagent, etc.

ACID NUMBER.

The acid number indicates the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in 1 gram of an oil, fat or wax.

Reagents. — Alcohol: redistilled, free from acids and aldehydes.

N/10 potassium (or sodium) hydroxide.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Cotton blue 6B solution: 2 grams to 100 cubic centimeters of alcohol. The indicator should be boiled in a flask under a reflux condenser for two hours and then filtered.

Method. — Ten grams of fat are brought into a 300 cubic centimeter Erlenmeyer flask, together with 100 cubic centimeters of alcohol and several glass beads. The flask is connected with a spiral or other form of reflux condenser and the solution brought to boil on a water bath to insure solution of the free fatty acids. The boiling should not be prolonged, as esterification is liable to result. The flask is then placed in a water bath at 60° C., and the solution after cooling to that temperature titrated with N/10 alkali, using 1 cubic centimeter of phenolphthalein as indicator, to the appearance of a pink tint. N/2 alkali is preferable for high percentages of free acids, preventing unnecessary dilution and cooling of the solution which otherwise might cause partial hydrolysis of the resulting soap[1] if the alcoholic strength fell below 40 per cent.[2] In practical work, however, at least 50 per cent. is advisable. As the change in color with phenolphthalein is gradual in many instances, without a sharply defined end point, cotton blue (1 cubic centimeter) offers certain advantages in such cases, as it yields a pronounced red and is more decisive. The coloration is not permanent with either indicator because of the saponification of neutral esters and the decolorizing action of carbonic acid absorbed from the air on shaking. Thorough shaking during titration, however, is essential, although the color persists for only a short time. Several blank determinations should be run on the alcohol with every series of tests, and deducted. Redistilled alcohol should be practically neutral, or can be readily made so by the addition of alkali.

1 cubic centimeter of N/10 alkali is equivalent to 5.6108 milligrams of potassium hydroxide.

Limit of error, 0.10 milligram.

Synopsis of Reaction.

$$RCOOH + KOH = RCOOK + H_2O$$

Supplementary Notes. — Koettstorfer expresses the acidity in cubic centimeters of N potassium hydroxide required for 100 grams of fat as "degrees of acidity." Stockmeier[3] reports "degrees of rancidity" in the same manner. Ten grams of fat with N/10 alkali are, however, a more convenient amount with which to work.

1° rancidity = .56108 acid number
1 acid number = 1.78228° rancidity

The amount of free acids in lubricating oils is sometimes reported in terms of sulfuric anhydride (SO_3).

The acid number of oils and fats varies with the purity, age and amount of hydrolysis and of oxidation they have undergone. Contact with fermenting or decaying matter, such as animal tissue, casein of butter and the marc of fruits, tends to rapidly increase the amount of free acids. Acidity is not a measure of rancidity, as hydrolysis may result from the action of enzymes (lipases) in the presence of moisture without accompanying oxidation, which appears necessary for the production of strong-smelling, acrid-tasting bodies (such as aldehydes, ketones, free volatile acids and esters of acids of low molecular weight) that characterize rancid products. Rancidity is due, apparently, to the simultaneous action of oxygen and of light on free fatty acids, and on glycerol. The latter does not seem to occur free, but appears to be decomposed immediately on formation. Rancidity develops more readily in liquid oils in which olein predominates than in the solid fats which are composed more largely of palmitin and stearin. Fresh animal fats are practically free from acid, while vegetable oils seem to contain a small amount. Relatively large amounts of free fatty acids are sometimes found in corn, sesame, peanut, rice, olive (especially "bagasse" olive oils), and Japanese sardine oils, in the so-called vegetable butters and tallows and other vegetable fats, particularly palm oil, and in bone fat, beef tallow and butter. The amount of free fatty acids in waxes is probably smaller and the variation less than in oils and fats, although carnauba wax and especially beeswax appear to contain considerable. In a measure, acid number indicates "quality" of the product.

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[1] On diluting and cooling a clear hot solution of neutral alkali palmitate or stearate (RCOOK), a precipitate containing more than one equivalent of fatty acids to one of alkali is produced, and the ratio tends to increase with greater dilution. Neutral oleate acts in a like manner, although investigators differ as to its relative stability. Holde claims that 80 per cent. alcohol is necessary to prevent hydrolysis of the oleate.

[2] Kanitz, Ber. Deut. Chem. Gesell. 1903, p. 400. (From Lewkowitsch.)

[3] Abstract, Vrtljschr. Chem. Nahr. u. Genussmtl. 4, pp. 428-429 (1889).

Mineral acids when present may be determined by shaking out with hot water in a separatory funnel, and by titrating the solution when cold with N/2 or N/10 alkali (according to the amount of acids present), using 1 cubic centimeter of methyl orange (1 to 1,000) as indicator. Methyl orange is not affected by carbonic acid, or by the insoluble fatty acids, and only to a limited extent by the soluble fatty acids, and is, therefore, well adapted for the purpose.

Mineral lubricating oils should not contain an appreciable amount of free acids. The acidity may be due to sulfuric acid from the refining process, to resinous bodies or to naphthenic acids. These acids should be neutralized with alkali and removed by washing or by sedimentation and filtration.

ETHER (ESTER) NUMBER.

The ether number indicates the number of milligrams of potassium hydroxide required for the saponification of the neutral esters in 1 gram of an oil, fat or wax.

The ether number is represented by the difference between the saponification and acid numbers, and in cases where there are no free fatty acids present is identical with the saponification number.

Supplementary Notes. — Natural fats, both animal and vegetable, contain practically only triglycerides, — neutral glyceryl esters. These glycerides may occur, however, to some extent as complex molecules (mixed triglycerides) instead of simple. The composition of mixed glycerides is difficult to determine, as they appear to suffer intramolecular changes on being treated with a solvent.

Monoglycerides and diglycerides apparently never occur in nature nor, to any appreciable amount, in freshly prepared oils and fats. The presence of free fatty acids indicates previous hydrolysis of the triglycerides, and hydrolysis conditions the presence of monoglycerides and diglycerides; therefore the so-called ether number loses its definite character as free acids increase.

CALCULATED DATA FROM SAPONIFICATION, ACID AND ETHER NUMBERS.

Glycerol. — In the saponification of any triglyceride, 3 molecules, or 168.324 parts, of potassium hydroxide combine with 1 molecule of fat, setting free 1 molecule, or 92.064 parts, of glycerol; therefore 1 gram of potassium hydroxide is equivalent to .54695 gram of glycerol.

$$\underset{\text{fat}}{(RCOO)_3C_3H_5} + \underset{\text{alkali}}{3\ KOH} = \underset{\text{glycerol}}{C_3H_5(OH)_3} + \underset{\text{salt}}{3\ RCOOK}$$

The percentage of glycerol (G) can be calculated from the ether number (e) by means of the formula[1] —

$$G = .00054695\ e \qquad (1)$$

This formula is not applicable in the case of fats containing monoglycerides and diglycerides. The higher the saponification number or, in other words, the lower the mean molecular weight of the constituent acids, the greater the proportion of glycerol. Monoglycerides and diglycerides contain a larger proportion of glycerol than the triglycerides.

Total Fatty Acids. — In the saponification of a fat, 3 molecules, or 54.048 parts, of water are required for every molecule, or 92.064 parts, of glycerol separated.

$$\underset{-}{(RCOO)_3C_3H_5} + \underset{54.048}{3\ H_2O} = \underset{92.064}{C_3H_5(OH)_3} + \underset{-}{3\ RCOOH}$$

The percentage of total fatty acids (T) in 1.00 part of fat can be calculated from the percentage of glycerol (G) by means of the formula[2] —

$$T = 1.00 + \frac{54.048}{92.064} G - G \quad \text{or}$$

$$1.00 - \frac{38.016}{92.064} G$$

and substituting the value of glycerol in terms of ether number (e): —

$$T = 1.00 - \left(\frac{38.016}{92.064} \times .00054695\ e\right) \quad \text{or}$$

$$1.00 - .00022585\ e \qquad (2)$$

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[1] Zulkowski, Ber. Deut. Chem. Gesell. 16, p. 1140.

[2] *Loc. cit.*, p. 1315.

In other words, assuming a fat to be composed of a mixture of triglycerides and free fatty acids, if the group C_3H_2 in an amount proportional to the glycerol content be deducted from 1.00, the percentage of total fatty acids may be obtained.

$$\underset{\text{Neutral fat}}{(RCOO)_3C_3H_5} + \underset{\substack{\text{Free}\\\text{fatty}\\\text{acids}}}{RCOOH} - C_3H_2 = \underset{\substack{\text{Total}\\\text{fatty}\\\text{acids}}}{4\ RCOOH}$$

$$T = 1.00 - \frac{38.016}{92.064}\,G \quad \text{or}$$

$$1.00 - .00022585\ e \tag{2}$$

In case of fats containing appreciable amounts of unsaponifiable matter proper correction should be made for the same.

Neutralization Number and Mean Molecular Weight of Total Fatty Acids. — The neutralization number (n) and mean molecular weight (m) of the total fatty acids (T) can be calculated from the ether (e) and saponification (s) numbers by means of the formulas —

$$n = \frac{s}{T} \quad \text{or}$$

$$\frac{s}{1.00 - .00022585\ e} \tag{3}$$

$$m = \frac{56108}{n} \tag{4}$$

Neutralization Number and Mean Molecular Weight of Fatty Acids in Neutral Fat. — The molecular weight (m_1) and neutralization number (n_1) of the acids in the neutral fat can be calculated from the ether number (e) and the percentage of neutral fat (N) — determined either gravimetrically or by difference[1] — by the formulas[2] —

$$\text{Molecular weight of neutral fat} = \frac{3 \times 56108}{e} \times N \quad \text{or}$$

$$\frac{168324\ N}{e}$$

$$\text{Molecular weight of neutral fat} = 3\,(m_1 - H) + C_3H_5 \quad \text{or}$$

$$3\,m_1 + C_3H_2 \quad \text{or}$$

$$3\,m_1 + 38.016$$

$$3\,m_1 + 38.016 = \frac{168324\ N}{e}$$

$$m_1 = \frac{56108\ N}{e} - 12.672 \tag{5}$$

$$n_1 = \frac{56108}{m_1} \tag{6}$$

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[1] The unsaponifiable matter is a source of error unless deducted.

[2] Wright, Analysis of Oils, etc., p. 130 (1903).

The neutralization number (n_1) and molecular weight (m_1) of the acids in the neutral fat can also be calculated from the ether number (e) and the percentage of total fatty acids (T) and free fatty acids (A) by the formula —

$$n_1 = \frac{e}{T - A} \qquad (7)$$

T — A may be derived from formulas (2) and (16).

$$m_1 = \frac{56108}{n_1} \qquad (8)$$

Mean Molecular Weight and Saponification Number of Neutral Fat. — The molecular weight (m_2) of the neutral fat can be calculated from the ether number (e) and the percentage of neutral fat (N) as shown above by the formula —

$$m_2 = \frac{3 \times 56108}{e} \times N \quad \text{or}$$

$$\frac{168324\ N}{e} \qquad (9)$$

or from the mean molecular weight (m_1) of the acids of the neutral fat: —

$$m_2 = 3\ m_1 + 38.016 \qquad (10)$$

The saponification number (s_2) can be calculated from the mean molecular weight (m_2) by means of the formula —

$$s_2 = \frac{3 \times 56108}{m_2} \qquad (11)$$

Fatty Acids and Glycerol in Neutral Fat. — The percentage of fatty acids (F) and of glycerol (G) in neutral fat can be calculated from the percentage of neutral fat (N) and the mean molecular weight (m_1) of the fatty acids in the neutral fat:[1] —

$$(RCOO)_3C_3H_5 + 3\ H_2O = 3\ RCOOH + C_3H_5(OH)_3$$

$$F = \frac{3\ m_1}{3\ m_1 + C_3H_2} \times N \qquad (12)$$

$$G = \frac{92.064}{3\ m_1 + 38.016} \times N \qquad (13)$$

The percentage of glycerol (G) in neutral fat (N) can also be calculated from the percentage (F) and molecular weight (m_1) of the acids of neutral fat by the formula —

$$N = \frac{3\ m_1 + C_3H_2}{3\ m_1} \times F \quad \text{or} \quad \frac{3\ m_1 + 38.016}{3\ m_1} \times F$$

$$G = \frac{C_3H_5(OH)_3}{3\ m_1 + C_3H_2} \times N \quad \text{or} \quad \frac{92.064}{3\ m_1 + 38.016} \times N$$

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[1] A close approximation can usually be obtained by using the mean molecular weight of the total fatty acids.

substituting the value of N in terms of F and m_1 : —

$$G = \frac{92.064}{3\,m_1 + 38.016} \times \frac{3\,m_1 + 38.016}{3\,m_1} \times F$$

$$\frac{92.064}{3\,m_1} \times F \qquad (14)$$

The total fatty acids are equal to the sum of the fatty acids in the neutral fat and the free fatty acids.

Percentage of Fatty Acids and Glycerol in Triglycerides.

Glycerides.	Formula.	Fatty Acids (Per Cent.).	Glycerol (Per Cent.).
Acetin,	$(CH_3COO)_3C_3H_5$	82.570	42.210
Butyrin,	$(C_3H_7COO)_3C_3H_5$	87.421	30.464
Valerin,	$(C_4H_9COO)_3C_3H_5$	88.957	26.743
Caproin,	$(C_5H_{11}COO)_3C_3H_5$	90.159	23.832
Caprylin,	$(C_7H_{15}COO)_3C_3H_5$	91.918	19.571
Caprin,	$(C_9H_{19}COO)_3C_3H_5$	93.144	16.603
Laurin,	$(C_{11}H_{23}COO)_3C_3H_5$	94.047	14.417
Myristin,	$(C_{13}H_{27}COO)_3C_3H_5$	94.740	12.739
Palmitin,	$(C_{15}H_{31}COO)_3C_3H_5$	95.288	11.411
Stearin,	$(C_{17}H_{35}COO)_3C_3H_5$	95.733	10.334
Arachin,	$(C_{19}H_{39}COO)_3C_3H_5$	96.101	9.443
Olein,	$(C_{17}H_{33}COO)_3C_3H_5$	95.704	10.405
Erucin,	$(C_{21}H_{41}COO)_3C_3H_5$	96.390	8.743
Linolin,	$(C_{17}H_{31}COO)_3C_3H_5$	95.674	10.476
Linolenin,	$(C_{17}H_{29}COO)_3C_3H_5$	95.644	10.549
Clupanodonin,	$(C_{17}H_{27}COO)_3C_3H_5$	95.614	10.623
Ricinolein,	$(C_{17}H_{32}.OH.COO)_3C_3H_5$	95.925	9.869
Dihydroxystearin,	$(C_{17}H_{33}(OH)_2COO)_3C_3H_5$	96.148	9.329

Free Fatty Acids. — The acid number (a) can be readily converted into percentage of free fatty acids (A) expressed as oleic, as sulfuric anhydride (SO_3), as an assumed acid with a molecular weight determined by formula (4), or as the acid of any other molecular weight (m_3).

$$A = \frac{a \times m_3}{56108} \qquad (15)$$

When the free acid or the predominant acid in a mixture is known it is often desirable to report acidity in terms of that acid. In such cases it is preferable to calculate the percentage directly from the titration by factor .0001 of the molecular weight of the acid (monobasic) for an N/10 solution, or .001 for N.

The percentage of acidity (A) can also be calculated from the acid number (a) and the neutralization number (n) of the total fatty acids.[1]

$$A = \frac{a}{n} \qquad \textbf{(16)}$$

The percentage of free fatty acids can be *estimated* approximately from the acid number (a) and saponification number (s): —

$$A = \frac{a}{s}$$

Neutral Fat and Unsaponifiable Matter. — The percentage of neutral fat and unsaponifiable matter can be determined by difference, — 1.00 minus per cent. of free fatty acids.

Neutral Fat and Free Fatty Acids. — The percentage of neutral fat (N) and free fatty acids (A) can be estimated from the ether number (e) by assuming an average saponification number (k) for the neutral product as basis for the calculation.

$$N = \frac{e}{k}$$

$$A = 1.00 - N$$

SOLUBLE FATTY ACIDS.

The soluble fatty acids in an oil, fat or wax indicate the percentage of fatty acids that is soluble in water.[2]

The percentage of soluble fatty acids can be readily calculated by difference, — total fatty acids less the insoluble. It is unnecessary to make the actual determination in most instances. When desired for some particular purpose, however, the test may be carried out as follows: —

Reagents. — Alcohol: redistilled, free from acids and aldehydes.

Alcoholic potash solution: 50 cubic centimeters of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of alcohol. The alkali should be added to the alcohol slowly, with agitation, in order to prevent any appreciable rise in temperature. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.

N/2 sulfuric acid.

N/2 potassium (or sodium) hydroxide.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Method. — Five grams of fat are brought into a 300 cubic centimeter Erlenmeyer flask, together with 50 cubic centimeters of alcoholic potash, accurately measured with a burette, and 50 cubic centimeters of alcohol. The flask is connected with a spiral or other form of reflux condenser and the solution boiled on a water bath with occasional rotation until saponification is complete, — about sixty minutes. The condenser is then removed and the flask placed in a water bath (immersed in the water) and the alcohol evaporated at a gradually increasing temperature, care being taken to prevent spattering. The last traces of alcohol, occluded in the soap, are expelled by breaking up the dry cake or by dissolving it in water and continuing the heating. Water to a volume of 100 cubic centimeters and 1 cubic centimeter of N/2 sulfuric acid in excess of that required to neutralize the 50 cubic centimeters of alcoholic potash are added, and the flask, connected with a spiral condenser, heated on a water bath until the separated fatty acids and underlying liquid become clear. From this point the process is conducted the same as for insoluble acids, using a spiral condenser to prevent loss of volatile acids. The combined filtrate and washings are titrated with N/2 potassium hydroxide, using phenolphthalein as indicator. The difference between the titration of the test and that of the excess N/2 acid (1 cubic centimeter) is the alkali equivalent of the soluble acids in the fat taken, which should be calculated to milligrams of potassium hydroxide for 1 gram of fat.

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[1] Strictly it should be the neutralization number of the free fatty acids. The number of cubic centimeters of N alkali required can be substituted in place of the values a and n.

[2] This may mean either hot or cold water, according to the method employed.

1 cubic centimeter of N/2 alkali is equivalent to 28.054 milligrams of potassium hydroxide.

The percentage of soluble fatty acids (S) is calculated from the number of milligrams of potassium hydroxide (k) required to neutralize the soluble acids in 1 gram of fat and the determined (or estimated) neutralization number (n) of the soluble acids by the formula —

$$S = \frac{k}{n}$$

Limit of error, 0.25 per cent.

Supplementary Notes. — The solubility of acids of the acetic series decreases with the increase in number of carbon atoms in the molecule. The so-called "soluble" acids include capric and all acids of less carbon atoms.

Acid.	Soluble in 100 Parts of Water.	
	15° C.	100° C.
Acetic (very soluble),[1]	∞	∝
Butyric (very soluble),	∝	∝
Valeric (soluble),	3.70	–
Caproic (difficultly soluble),	.882	–
Caprylic (insoluble),	.079	.25
Capric (insoluble),	–	.10

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[1] Solubility based on Mulliken's classification, Identification of Pure Organic Compounds, 1, p. 38 (1911): —

	One Gram in —	Grams in 100 c. c.
Very soluble,	5 c. c.	20
Easily soluble,	5– 20 c. c.	20–5
Soluble,	20– 50 c. c.	5–2
Difficultly soluble,	50–150 c. c.	2–.66
Very difficultly soluble,	150–500 c. c.	.66–.2
Insoluble,	500 c. c. and over.	.2 and under.

Lauric is classed as "insoluble," although slightly soluble in boiling water.

A soluble dibasic acid occurs in Japan wax which is not volatile.

Neutralization Number. — The neutralization number indicates the number of milligrams of potassium hydroxide required to neutralize 1 gram of soluble fatty acids.

The difference between the saponification number (s) of the fat and the product of the percentage of insoluble fatty acids (I) times their neutralization number (n_1) indicates the milligrams of potassium hydroxide required to neutralize the soluble fatty acids in 1 gram of fat, which, divided by the percentage of soluble fatty acids (S), gives the neutralization number (n) of the soluble fatty acids.

$$n = \frac{s - In_1}{S}$$

Mean Molecular Weight. — The molecular weight (m) of the soluble fatty acids can be calculated from the neutralization number (n) by means of the formula —

$$m = \frac{56108}{n}$$

Neutralization Numbers of Soluble Fatty Acids.

ACID.	Formula.	Molecular Weight.	Neutralization Number.
Acetic,	CH_3COOH	60.032	934.635
Butyric,	C_3H_7COOH	88.064	637.128
Valeric,	C_4H_9COOH	102.080	549.647
Caproic,	$C_5H_{11}COOH$	116.096	483.290
Caprylic,	$C_7H_{15}COOH$	144.128	389.293
Capric,	$C_9H_{19}COOH$	172.160	325.906

Glycerides of Soluble Fatty Acids. — The percentage of triglycerides (Sg) can be calculated from the percentage (S) and molecular weight (m) of the soluble fatty acids by the formula —

$$Sg = \frac{3\,m + 38.016}{3\,m} \times S$$

Glycerol in the Glycerides of Soluble Acids. — The percentage of glycerol (G) in the glycerides of soluble acids can be calculated from the percentage (S) and molecular weight (m) of the soluble acids: —

$$G = \frac{92.064}{3\,m} \times S$$

See derivation of formula (14) and table "Percentage of Fatty Acids and Glycerol in Triglycerides."

Mean Molecular Weight and Saponification Number of the Glycerides of Soluble Acids. — The mean molecular weight (m_2) and saponification number (s_2) of the glycerides of the soluble acids can be calculated from the molecular weight (m) of the soluble acids: —

$$m_2 = 3\,m + 38.016$$

$$s_2 = \frac{3 \times 56108}{m_2}$$

See table "Saponification Number of Triglycerides."

From the above formulas factors were deduced for the soluble acids enumerated below, by means of which the percentage of triglycerides and of glycerol may be calculated readily from the percentage of fatty acids.

Acid.	Factor for Per Cent. of Triglycerides.	Factor for Per Cent. of Glycerol.
Acetic,	1.21109	.51119
Butyric,	1.14390	.34847
Valeric,	1.12414	.30063
Caproic,	1.10915	.26433
Caprylic,	1.08792	.21292
Capric,	1.07361	.17825

Reichert-Meissl Number.

The Reichert-Meissl number[1] indicates the number of cubic centimeters of N/10 potassium hydroxide required to neutralize that portion of the volatile fatty acids which is obtained from 5 grams of an oil, fat or wax by the Reichert distillation process.[2]

Reagents. — Glycerol potash solution: 120 grams of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of pure glycerol, heated sufficiently to dissolve the alkali (about 115° C.).

Sulfuric acid: 1 to 4.

N/10 potassium (or sodium) hydroxide.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Method. — Into an Erlenmeyer flask of 300 cubic centimeters capacity are brought 5 grams of fat, care being taken to avoid getting any fat on the sides of the flask, together with 20 cubic centimeters of glycerol potash, heated over a small naked flame and rotated continuously until the saponification is complete, as shown by the solution becoming perfectly clear. Care should be taken not to overheat and discolor the material. The soap when cold should be absolutely free from globules of fat. Ten grams of glass beads,[1] 135 cubic centimeters of recently boiled distilled water, and 5 cubic centimeters of sulfuric acid (1 to 4) are added, and the flask connected with a Liebig condenser.[2] (See Fig. 3.) The mixture is heated on 16-mesh Ni-chrome wire gauze at low ebullition, until the separated fatty acids and underlying liquid become *clear*. One hundred and ten cubic centimeters are then distilled as nearly as possible in thirty minutes, and received in a graduated flask. The flame should be well oxidized to induce vigorous agitation of the beads, thus assuring a more thorough separation of the volatile acids. The distillate is thoroughly mixed and passed through a dry, dense filter to remove all traces of higher fatty acids that appear as oily drops or white solid particles. One hundred cubic centimeters are pipetted into an Erlenmeyer flask and titrated with N/10 alkali, using 1 cubic centimeter[3] of phenolphthalein as indicator, avoiding entirely the addition of water. The pink coloration should hold several minutes. Care should be exercised at all times during the process to prevent the absorption of carbonic acid. Blank determinations should be run with every new lot of reagents. The titration reading,

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[1] The Reichert-Meissl number is about 2.2 times as great as the Reichert. — Lewkowitsch, Analysis of Oils, Fats and Waxes, 1, p. 417, (1913).

[2] Ztschr. Analyt. Chem. 18, pp. 68–73 (1879).

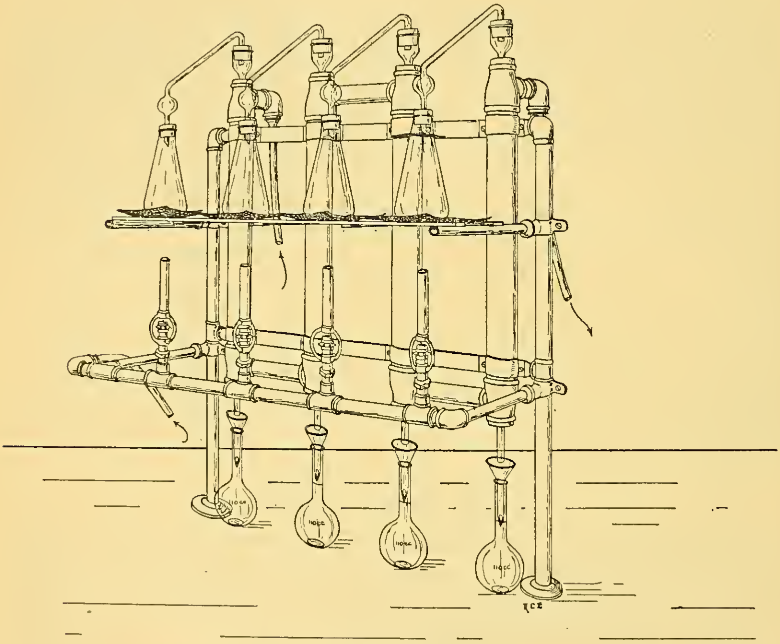

FIG. 3. — Distillation apparatus employed in the determination of Reichert-Meissl number.

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[1] Weighing approximately one-half gram each.

[2] A vertical condenser with a rapid circulation of cold water is preferable.

[3] A definite quantity is necessary if the mean molecular weight is to be determined.

multiplied by 1.1, minus the blank, and reduced to a 5-gram fat basis, is the Reichert-Meissl number.

Limit of error, 0.25 cubic centimeter.

Synopsis of Reaction.

$$\underset{\text{fat}}{(RCOO)_3C_3H_5} + \underset{\text{alkali}}{3\,KOH} = \underset{\text{salt}}{3\,RCOOK} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

The glycerol acts as a transmitter of heat, having a boiling point of 290° C.

$$2\,RCOOK + H_2SO_4 = 2\,RCOOH + K_2SO_4$$

Distillation of the volatile acids. Titration.

Supplementary Notes. — As this method is only an arbitrary one it is essential to adhere strictly to the conditions of operation as laid down if comparative results are to be obtained, and by so doing over 80 per cent. of the soluble acids in butter can be secured in the distillate. Jensen states that the Reichert process[1] yields with butter fat 85 to 88 per cent. of the total butyric, 24 to 25 per cent. of the caprylic, and 85 to 100 per cent. of the capric acids. Repeated distillation yields higher results, but is accompanied by decomposition of the nonvolatile acids. Glycerol potash is preferable to alcoholic potash in that it shortens the process and prevents possible loss due to the formation of esters during saponification. Sodium hydroxide has greater basicity than potassium hydroxide, but the resulting hard soap is less soluble. The fatty acids appear to have practically the same affinity for both hydroxides.

Acetic, butyric, valeric, caproic, caprylic and capric are the only fatty acids that can be distilled under ordinary pressure without decomposition. These acids have comparatively high boiling points, as shown by the following table, but owing to their high vapor tension they can be readily distilled from aqueous solutions with steam, and are termed "volatile" acids: —

Acids.	Boiling Point (° C.).
Acetic,	118.1
Butyric,	162.3
Valeric,	186.0–186.4
Caproic,	202.0–203.0
Caprylic,	236.0–237.0
Capric,	268.0–270.0

The boiling points rise with the increase in molecular weight. Lauric acid is very slightly volatile in a current of steam. The nonvolatile acids when distilled at ordinary pressure undergo partial decomposition and yield hydrocarbons of the ethane and possibly other series. In vacuo they can be distilled with or without superheated steam.

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[1] Ztschr. Untersuch. Nahr. u. Genussmtl. 1905, p. 272.

Most of the natural fats and oils contain but a small amount of volatile (soluble) fatty acids, generally below 2 Reichert-Meissl number. Some prominent exceptions have already been enumerated, being characterized by saponification numbers exceeding 210. See supplementary notes under "Saponification Number." The high Reichert-Meissl numbers of dolphin and porpoise oils may be due to valeric acid. The amount of volatile or soluble acids in those oils and fats whose saponification number does not exceed 195 is inappreciable.

Among the oils and fats with a high volatile acid content might be mentioned[1] myrtle seed oil, croton oil, oleander oil, senega root oil, lycopodium oil, apeiba oil, dolphin oil, macassar oil, muriti fat, mocaya oil, palm kernel oil, coconut oil and tonka butter, having Reichert-Meissl numbers between 5 and 15; and spindle tree oil, malukang oil, dolphin jaw oil, porpoise body oil, porpoise jaw oil, brown fish oil and butter fat, having Reichert-Meissl numbers ranging from 25 to 50, or even greater in some instances.

The amount of volatile acids is likely to increase with the age of the sample.

The results of Wechsler[2] and other investigators indicate that volatile acids of higher molecular weight distill over before the lower acids, especially in cases where the neutrality of the solution is destroyed gradually by several additions of acid instead of one, thus fractionating the distillates.

Neutralization Number and Mean Molecular Weight. — The titrated volatile acids[3] resulting from the determination of the Reichert-Meissl number are evaporated in a tared platinum dish and dried to constant weight in an oven at 100° C. From the weight (w) of the salts and the quantity (v) of N/10 alkali used, the mean molecular weight (m) and the neutralization number (n) can be calculated by the formulas —

$$\mathrm{RCOONa} - \mathrm{Na} + \mathrm{H} = \mathrm{RCOOH}$$

$$m = \frac{40.008\ (w - .0021992\ v)}{.0040008\ v}$$

$$m = \frac{10000\ (w - .0021992\ v)}{v}$$

$$n = \frac{56108}{m}$$

Blank determinations should be run with every new lot of reagents, both by distillation (Reichert-Meissl number) and by evaporation of the titrated portion (salts), and deducted in the calculation.

Limit of error, 1 unit molecular weight.

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[1] Lewkowitsch, Analysis of Oils, Fats and Waxes, 1, p. 423 (1913).

[2] Jour. Soc. Chem. Indus., 1894, p. 179. (From Lewkowitsch.)

[3] Using N/10 sodium hydroxide, prepared from caustic alkali that is free from carbonate and other impurities. The solution should be filtered frequently to remove silica arising from decomposition of the glass.

Volatile Acids.

The percentage of volatile acids (V) can be calculated from the weight (w) of the salts obtained, the quantity (v) of N/10 alkali used (as shown above), and the weight (w_1) of fat taken for the Reichert-Meissl determination by the formula —

$$V = \frac{1.1\ (w - .0021992\ v)}{w_1}$$

The percentage of volatile acids (V) can be calculated in a like manner from the Reichert-Meissl number and the neutralization number (n) of the volatile acids by the formula —

$$V = \frac{0.2\ \text{R-M. No.}\ \times 5.6108}{n}$$

Formulas for calculating the amount of *triglycerides* of the volatile fatty acids, the *mean molecular weight* and *saponification number* of the triglycerides, and *glycerol* content will be found under like headings of "Soluble Acids."

Polenske Number.

The Polenske number indicates the number of cubic centimeters of N/10 potassium hydroxide required to neutralize that portion of the insoluble volatile acids which is obtained from 5 grams of an oil, fat or wax by the Reichert distillation process.

Reagents. — Glycerol potash solution: 120 grams of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of pure glycerol, heated sufficiently to dissolve the alkali (about 115° C.).

Sulfuric acid, 1 to 4.

Alcohol: redistilled, free from acids and aldehydes.

N/10 potassium (or sodium) hydroxide.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Cotton blue 6B solution: 2 grams to 100 cubic centimeters of alcohol. The indicator should be boiled in a flask under a reflux condenser for two hours and then filtered.

Method. — The method can be conducted in connection with the Reichert-Meissl test, and may be considered supplementary to it. A vertical condenser should be employed with a circulation of water adequate to chill the distillate to 20° C., and the test carried out as usual. The resulting distillate is chilled fifteen minutes at 15° C., carefully mixed by reversing the flask several times (avoiding any shaking), and poured through a dry 11 centimeter filter. The condenser, 110 cubic centimeter flask and filter are washed three times in succession with 15 cubic centimeter portions of water to remove soluble acids, and the wash waters thrown away. The insoluble volatile acids in the condenser, 110 cubic centimeter flask and filter are dissolved in alcohol and titrated with N/10 alkali, using 1 cubic centimeter of phenolphthalein as indicator. The titration reading minus the blank, reduced to a 5-gram basis, is the Polenske number.

Limit of error, 0.10 cubic centimeter.

Synopsis of Reaction. — Solution of insoluble volatile acids in alcohol. Titration.

Supplementary Notes. — The Polenske number for most oils and fats having a saponification number of about 195 rarely exceeds .65, unless the product is excessively acid or rancid.[1] The Polenske number of butter fat is about 2 to 3, of palm kernel oil, 10 to 12, and of coconut oil, 15 to 20.

INSOLUBLE FATTY ACIDS AND UNSAPONIFIABLE MATTER (HEHNER NUMBER).[2]

The insoluble fatty acids in an oil, fat or wax indicate (unless otherwise stated) the percentage of fatty acids and unsaponifiable matter that is insoluble in water.[3]

Reagents. — Glycerol potash solution: 120 grams of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of pure glycerol, heated sufficiently to dissolve the alkali (about 115° C.).

Sulfuric acid: 1 to 4.

Ceresine: pure white, filtered.

Ethyl ether: anhydrous and free from alcohol and residue.

Method. — Five grams of fat are brought into a 300 cubic centimeter Erlenmeyer flask, together with 20 cubic centimeters of glycerol potash, and heated over a small naked flame, rotating continuously until the saponification is complete, as shown by the solution becoming perfectly clear. Care should be taken not to overheat and discolor the material. The resulting soap, absolutely free from globules of fat, is dissolved in 150 cubic centimeters of hot water and decomposed with a slight (few drops) excess of sulfuric acid (1 to 4).[4] The flask is heated on a water bath with occasional agitation, until the separated fatty acids and underlying liquid become clear. This requires a number of hours, generally overnight, and must not be slighted. The flask is immersed in cold water[5] to solidify the fatty acids, after which the solution is decanted through a dense, ether-extracted filter,[6] care being taken not to break the insoluble cake. One hundred and fifty cubic centimeters of boiling water are added, thoroughly agitated, heated as above, cooled and decanted, the process being repeated until the washings are free from acid. Litmus paper is not sufficiently sensitive for this purpose. The final 150 cubic centimeters of filtrate should give a decided color with three or four drops of N/10 alkali, using phenolphthalein as indicator. In those cases where caprylic and particularly capric acids are present the filtrate may give an appreciable acid reaction after 10 to 15 washings. The treatment should be continued until the acidity of the filtrate is less than 0.25 cubic centimeter N/10 solution.

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[1] Lewkowitsch, Analysis of Oils, Fats and Waxes, 1, p. 426 (1913).

[2] Angell and Hehner, Butter: Its Analysis and Adulteration (1874).

[3] This may mean either hot or cold water, according to the method employed.

[4] About 5 cubic centimeters are required.

[5] A flat-bottomed "plug" sink with the outlet closed with a perforated cork, carrying a piece of glass tubing to regulate the height of the water, serves quite satisfactorily as a chilling bath.

[6] Baker & Adamson Chemical Company, 12.5 centimeters washed filter paper, "B" dense.

In determining the insoluble acids of oils and fats having a low solidifying point, the addition of .5 to 1 gram of ceresine[1] before treating with sulfuric acid greatly facilitates subsequent work, and serves to protect the unsaturated acids from decomposition.

The filter and inverted flask containing the cake of insoluble fatty acids are allowed to drain in a cool place until practically dry. A convenient filter stand for both filtration and draining is illustrated by Wiley.[2] The small particles of fat adhering to the filter are dissolved in ether in a continuous fat extractor[3] run into the flask, and the ether expelled in the usual manner. The ether fumes are very persistent and necessitate blowing out the flask with hand bellows. The insoluble acids are dried in an oven at 100° C., or in a vacuum oven at 70° C., to approximately constant weight. At 100° C. the drying periods should not exceed two hours. The weight of the flask is determined at the completion of the test, to offset the solvent action of the reagents on the glass. Blanks should be run on every new lot of ceresine to determine the amount (if any) of soluble material present.

There are compensating errors that usually result from this method, namely, volatilization of fatty acids, dehydration of simple and of hydroxy fatty acids with the formation of anhydrides and of lactones, respectively, and oxidation of unsaturated acids.[4] Drying in a vacuum oven at 70° C., in a current of carbonic acid gas or even of dry air, will reduce oxidation as well as dehydration and volatilization.

Limit of error, 0.25 per cent.

Synopsis of Reaction. — Similar to those of Reichert-Meissl number.

Supplementary Notes. — Differences in chemical structure of the insoluble fatty acids permit of their classification into saturated, unsaturated, hydroxy acids, etc.

The principal saturated acids are lauric, myristic, palmitic, stearic, arachic and dihydroxystearic.

The most prominent unsaturated acids are oleic, erucic, linolic, linolenic, clupanodonic and ricinoleic. When these acids are compared with the empirical formula for saturated acids, $C_nH_{2n+1}COOH$, they show a deficiency of 2, 4, 6 or 8 atoms of hydrogen, which indicates their power to absorb iodine chloride with the formation of additive compounds.

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[1] The amount required varies with the consistency of the insoluble acids that are being determined.

[2] Foods and Food Adulterants, U. S. Dept. Agr., Bur. Chem., Bul. 13, p. 457.

[3] See Fig. 4, page 136.

[4] Saturated acids do not readily absorb oxygen. Unsaturated acids of the linolic and linolenic series absorb oxygen from the air at ordinary temperatures, and of the oleic series at higher temperatures.

Members of the chaulmoogric and tariric series constitute an exception to the above statement. (See "Calculated Data from the Iodine Number.") Unsaturated acids containing an open chain of 18 carbon atoms (oleic, linolic, linolenic acids, etc.) are reduced by hydrogen in the presence of a suitable catalyzer (nickel or colloidal palladium) to stearic acid.

Dihydroxystearic and ricinoleic acids are hydroxy acids which on acetylation assimilate an acetyl radical (CH_3CO) in place of the hydrogen in every alcoholic hydroxyl group.

Most fats and oils contain from 93 to 96 per cent. of insoluble acids, with a mean of approximately 95. Some notable exceptions, having saponification numbers exceeding 210 and a high volatile acid content, have already been mentioned. The fatty acids are practically all insoluble where the saponification number of an oil or fat does not exceed 195. Croton oil contains about 89 per cent. of insoluble acids and unsaponifiable matter; dolphin jaw oil, 66 per cent.; porpoise jaw oil, 70 per cent.; brown fish oil, 85.5 per cent.; laurel oil, 83.5 to 87 per cent.; palm nut oil, 87.5 to 91 per cent.; coconut oil, 88.5 to 90 per cent.; Japan wax, 90.5 per cent.; and butter fat, 86.5 to 90 per cent.

In liquid waxes the amount of insoluble fatty acids free from alcohols and hydrocarbons varies from 60 to 65 per cent., and in solid waxes from 47 to 60 per cent.

The acid content of palmitin is 95.29, stearin 95.73, olein 95.70, linolein 95.67 and linolenin 95.64 per cent.; therefore the percentage of insoluble acids in most oils and fats free from appreciable amounts of the lower fatty acids and of unsaponifiable matter must be in the vicinity of 95.

Preparation of Insoluble Acids.

The method for preparing insoluble fatty acids for analysis is the same as described for the determination of "Insoluble Acids," with the elimination of such features as are necessary only for quantitative work. About 28.5 cubic centimeters (25 grams) of the melted fat or oil are pipetted into a 750 cubic centimeter Erlenmeyer flask, together with 100 cubic centimeters of glycerol potash, and saponified. The resulting soap is dissolved in 500 cubic centimeters of hot water, decomposed with a slight excess (few drops) of sulfuric acid (1 to 4), and heated on a water bath, with occasional agitation, until the separated fatty acids and underlying liquid become clear. Several such charges will furnish sufficient material for the analysis. The fatty acids may be washed as described under "Insoluble Acids," or the contents of the flasks transferred to a separatory funnel and washed by shaking out with hot water,[1] until free from soluble acids. The latter modification has some advantages, particularly for insoluble acids of low melting point. Thorough washing may not always insure the entire removal of caprylic and capric acids when present, but the treatment should not be unduly prolonged for fear of injury to the unsaturated acids. The melted fatty acids are run into a test tube, heated in a water bath at 60° C. to allow any water present to settle out, filtered in a jacketed funnel, and preserved in a well-stoppered bottle in a cool dark place. The above process should yield fatty acids practically free from decomposition. It is inadvisable to employ the residue from the quantitative determination of the insoluble acids for further tests.

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[1] The layer of fatty acids should be allowed to partially solidify at least, before the water is drawn off, to insure conditions similar to those prevailing in the quantitative determination of the insoluble acids.

Neutralization Number.

The neutralization number indicates the number of milligrams of potassium hydroxide required for the complete neutralization of 1 gram of insoluble fatty acids by the saponification process.

Reagents. — Alcohol: redistilled, free from acids and aldehydes.

Alcoholic potash solution: 50 cubic centimeters of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of alcohol. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.

N/2 hydrochloric acid.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Cotton blue 6B solution: 2 grams to 100 cubic centimeters of alcohol. The indicator should be boiled in a flask under a reflux condenser for two hours and then filtered.

Method. — Into a 300 cubic centimeter Erlenmeyer flask are brought 5 grams of insoluble fatty acids, together with 50 cubic centimeters of alcoholic potash accurately measured with a burette, 50 cubic centimeters of alcohol and several glass beads. The flask is then connected with a spiral or other form of reflux condenser and the solution boiled on a water bath with occasional rotation until the reaction is complete, — about sixty minutes. The flask is then placed in a water bath at 60° C., and the solution, after cooling to that temperature, titrated with N/2 hydrochloric acid, using 1 cubic centimeter of phenolphthalein or cotton blue as indicator. For further details see "Saponification (Koettstorfer) Number." The difference between the titration of the blank and that of the excess alkali of the test is the acid equivalent of the insoluble acids taken, which should be calculated to milligrams of potassium hydroxide for 1 gram of insoluble acids. In all cases where the unsaponifiable matter constitutes an appreciable amount it should be deducted in calculating the neutralization number of the insoluble fatty acids, and so stated.

1 cubic centimeter of N/2 acid is equivalent to 28.054 milligrams of potassium hydroxide.

Limit of error, 0.50 milligram.

Synopsis of Reaction. — See "Acid Number" with titration of excess alkali, as in "Saponification Number."

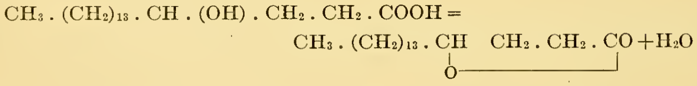
Mean Molecular Weight. — The molecular weight (m) of the insoluble fatty acids can be calculated from the neutralization number (n) by means of the formula —

$$m = \frac{56108}{n}$$

or directly from the acid equivalent (v) and weight (w) of insoluble fatty acids taken: —

$$m = \frac{2000\ w}{v}$$

Supplementary Notes. — Direct titration of the fatty acids in alcohol with N/2 alkali in a manner similar to that of "Acid Number" is often recommended, although the process tends to yield low neutralization numbers,[1] probably due to the presence of lactones (inner anhydrides of hydroxy acids) or of anhydrides of simple fatty acids, which do not combine with aqueous alkali in the cold, but readily hydrolyze on boiling with alcoholic potash. The lactones and anhydrides may result from drying under unfavorable conditions. Marked differences between the two methods are shown in the references cited. In our hands, working with purified insoluble fatty acids, only slight differences were obtained except in the case of oleic acid. The saturated acids were prepared with special precautions and dried at a low temperature, which precluded the possibility of forming anhydrides. Hydroxy acids, such as ricinoleic acid of castor oil, are particularly likely to dehydrate with the formation of inner anhydrides. Lactones occur naturally or are readily formed from the fatty acids of Sewarri fat and of wool wax. In the latter case they result to some extent from heating at 100° C. The fatty acids of castor oil polymerize on long standing even at ordinary temperature to polyricinoleic acid. Gamma hydroxystearic acid on losing a molecule of water forms stearolactone, and may serve as an example (Lewkowitsch): —



$$CH_3 . (CH_2)_{13} . CH . (OH) . CH_2 . CH_2 . COOH =$$
$$CH_3 . (CH_2)_{13} . \underset{\textstyle O}{CH}\ \ CH_2 . CH_2 . \underset{\textstyle O}{CO} + H_2O$$

The neutralization numbers of the mixed insoluble acids of most vegetable and animal oils and fats range from 185 to 215, averaging about 200, with the exception of the vegetable fats of the myristica, coconut oil and dika fat groups which range from about 252 to 271.

The neutralization numbers of the mixed insoluble acids of some of the more prominent oils and fats are linseed oil, 200; corn oil, 200; cottonseed oil, 205; sesame oil, 200; rape oil, 185; peanut oil, 202; olive oil, 201; castor oil, 192; cod liver oil, 205; palm oil, 207; cacao butter, 190; palm nut oil, 261; coconut oil, 271; lard, 205; beef tallow, 208; and butter fat, 215 to 225. These figures are reasonably accurate in most instances.

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[1] Tortelli and Pergami, Chem. Rev. Fett u. Harz Indus., 9, pp. 182, 204 (1902); Lewkowitsch, Analysis of Oils, Fats and Waxes, 1, pp. 518, 519 (1913).

Neutralization Number of Insoluble Fatty Acids.

ACID.	Formula.	Molecular Weight.	Neutralization Number.
Lauric,	$C_{11}H_{23}COOH$	200.192	280.271
Myristic,	$C_{13}H_{27}COOH$	228.224	245.846
Palmitic,	$C_{15}H_{31}COOH$	256.256	218.953
Stearic,	$C_{17}H_{35}COOH$	284.288	197.363
Arachic,	$C_{19}H_{39}COOH$	312.320	179.649
Oleic,	$C_{17}H_{33}COOH$	282.272	198.773
Erucic,	$C_{21}H_{41}COOH$	338.336	165.835
Linolic,	$C_{17}H_{31}COOH$	280.256	200.203
Linolenic,	$C_{17}H_{29}COOH$	278.240	201.653
Clupanodonic,	$C_{17}H_{27}COOH$	276.224	203.125
Ricinoleic,	$C_{17}H_{32}.OH.COOH$	298.272	188.110
Dihydroxystearic,	$C_{17}H_{33}(OH)_2COOH$	316.288	177.395

Glycerides of Insoluble Fatty Acids. — The percentage of triglycerides (Ig) can be calculated from the percentage (I) and molecular weight (m) of the insoluble fatty acids by the formula —

$$Ig = \frac{3\,m + 38.016}{3\,m} \times I$$

Glycerol in the Glycerides of Insoluble Acids. — The percentage of glycerol (G) in the glycerides of insoluble acids can be calculated from the percentage (I) and molecular weight (m) of the insoluble acids: —

$$G = \frac{92.064}{3\,m} \times I$$

See derivation of formula (14) and table "Percentage of Fatty Acids and Glycerol in Triglycerides."

Mean Molecular Weight and Saponification Number of the Glycerides of Insoluble Acids. — The mean molecular weight (m_1) and saponification number (s_1) of the glycerides of the insoluble acids can be calculated from the molecular weight (m) of the insoluble acids: —

$$m_1 = 3\,m + 38.016$$

$$s_1 = \frac{3 \times 56108}{m_1}$$

See table "Saponification Number of Triglycerides."

From the above formulas factors were deduced for the insoluble acids enumerated below, by means of which the percentage of triglycerides and of glycerol may be readily calculated from the percentage of fatty acids: —

Acid.	Factor for Per Cent. of Triglycerides.	Factor for Per Cent. of Glycerol.
Lauric,	1.06330	.15329
Myristic,	1.05552	.13446
Palmitic,	1.04945	.11976
Stearic,	1.04457	.10795
Arachic,	1.04057	.09826
Oleic,	1.04489	.10872
Erucic,	1.03745	.09070
Linolic,	1.04522	.10950
Linolenic,	1.04554	.11029
Clupanodonic,	1.04588	.11110
Ricinoleic,	1.04248	.10289
Dihydroxystearic,	1.04006	.09703

Lactones and Anhydrides.

The amount of lactones and anhydrides present in the separated insoluble acids of oils and fats can be measured in terms of milligrams of potassium hydroxide by the difference in the amount of alkali required to titer (neutralize) the acids in cold alcohol and that absorbed on saponifying with alcoholic potash. Lactones and anhydrides are unable to combine with alkali until transformed into acids. They are not hydrolyzed to any considerable extent in cold alcohol, but are readily hydrolyzed by boiling alcoholic potash.

Reagents. — Same as for "Acid" and "Saponification" numbers.

Method. — Five grams of insoluble fatty acids are brought into a 300 cubic centimeter Erlenmeyer flask, together with 100 cubic centimeters of alcohol, and titrated in the cold with N/2 potassium hydroxide, using 1 cubic centimeter of phenolphthalein or cotton blue as indicator. An additional 5 grams of insoluble acid are brought into a flask and treated exactly as described for saponification number. The difference between the two determinations, in terms of milligrams of potassium hydroxide to the gram of insoluble acids, measures the amount of lactones and anhydrides present. The same weight of fat may serve for both determinations if desired.

Limit of error, same as in the determinations of acid and saponification numbers.

Synopsis of Reaction. — Solution in alcohol.

Neutralization: —

$$\underset{\text{acid}}{RCOOH} + \underset{\text{lactone}}{ROCO} + \underset{\text{anhydride}}{(RCO)_2O} + KOH = RCOOK + ROCO + (RCO)_2O + H_2O$$

Saponification: —

$$RCOOH + ROCO + (RCO)_2O + 4\ KOH$$
$$= RCOOK + R\ .\ OH\ .\ COOK + 2\ RCOOK + 2\ H_2O$$

When the lactone or anhydride in the insoluble acids, or the predominant one in a mixture, is known, the percentage (L) can be calculated from the determined alkali equivalent[1] (l), — *i.e.*, saponification number less acid number of insoluble acids, and the theoretical saponification number (k) of the lactone or anhydride, — by the formula —

$$L = \frac{l}{k}$$

Iodine Number.

The iodine number indicates the percentage of iodine chloride absorbed under definite conditions by the insoluble fatty acids, expressed in terms of iodine.

See method for oils and fats.

The iodine number of insoluble acids does not necessarily correspond to that of the natural oil, fat or wax from which the acids were derived. This is said to be due to the influence of soluble fatty acids in the natural product, although it is probable that in the process of separation some decomposition of the unsaturated acids results.

Insoluble acids after titration with thiosulfate undergo a reversible reaction and split off iodine much more rapidly than the oils and fats from which they were derived.

Acetyl Number.

The acetyl number indicates the number of milligrams of potassium hydroxide required to combine with the acetyl absorbed by 1 gram of insoluble fatty acids on acetylation.

See method for oils and fats.

The acetylated product should be washed until the acidity of the filtrate (150 cubic centimeters) is less than 0.25 cubic centimeter N/10 solution.

Stearic Acid.

The stearic acid indicates the percentage of that acid in the insoluble fatty acids of an oil or fat.

Reagents. — Alcoholic-stearic solution: 3 grams of crystalline stearic acid of theoretical molecular weight to 1,000 cubic centimeters of purified alcohol[1] of about 95.25 per cent., heated sufficiently to give a clear solution.

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[1] Lactone number.

Ethyl ether: free from residue.

Apparatus. — Eight-ounce sterilizer bottles[2] of narrow cylindrical form ($6\frac{3}{4}$ by 2 inches).

Small thistle tubes ($\frac{1}{4}$-inch bulb) with a felt of absorbent cotton, weighing .02 gram, supported by a glass bead and covered by a piece of cheesecloth.

Ice tank of $\frac{7}{8}$-inch material (approximately 20 inches long, 10 inches wide and 20 inches deep), lined with galvanized iron, provided with a tight cover, and supported by legs to a convenient working height.

For icing, a basket ($13\frac{1}{2}$ by 6 by 18 inches) of galvanized screening of $\frac{5}{16}$-inch mesh.

Pockets of galvanized screening to support the bottles so that only a small portion of the neck projects out of the ice water.

A pump or agitator run by motor to keep the water in continuous circulation.

Method. — Five-tenths of a gram of melted insoluble acids are brought into an 8-ounce sterilizer bottle, and 150 cubic centimeters of an alcoholic-stearic solution, accurately measured with a pipette at 30° C., added. The bottle is sealed with a solid rubber stopper, shaken at a gradually increasing temperature until a clear solution is obtained, immediately placed in a pocket of the ice tank and allowed to stand overnight. The following morning the solution is gently agitated by inverting the bottle several times, and in the afternoon is siphoned off as thoroughly as possible by means of a small thistle tube[3] and a perforated rubber stopper, using suction. The residue is dissolved in ethyl ether, transferred to a tared 140 cubic centimeter wide-mouthed Erlenmeyer flask, the ether carefully distilled off, dried at 100° C., and weighed. As saturation may vary somewhat with the amount of stearic acid present, and as the quantity of solution retained by the precipitate depends in a measure on the amount of precipitate, blanks are run on a weight of stearic acid equivalent to that expected in the test. By deducting the additional stearic acid taken, from the weight recovered, the true blank for the alcoholic-stearic solution is obtained.

The molecular weights of the precipitates should be determined occasionally to check the operation. In the presence of palmitic acid it has been found necessary to increase the amount of stearic acid in solution in order to counteract the solvent action of the former acid.

Limit of error, from 0.50 to 0.75 per cent.

Synopsis of Reaction. — Solution of insoluble fatty acids in alcoholic-stearic solution.

Crystallization of stearic acid under control conditions.

Filtration.

Recovery and weight of precipitate.

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[1] See "Reagents," under "Saponification Number."

[2] Manufactured by Whitall Tatum Company, Philadelphia, Pa.

[3] The size of the tube and preparation of the felt have already been described.

Iodine Number.

The iodine number indicates the percentage of iodine chloride absorbed under definite conditions by an oil, fat or wax, expressed in terms of iodine.

Reagents. — Iodine solution according to Wijs.[1] Thirteen grams of resublimated iodine to 1,000 cubic centimeters of acetic acid[2] (99.5 per cent.), free from oxidizable products. After the iodine is completely dissolved the solution is treated with pure dry chlorine gas[3] until the iodine has been converted into monochloride. The completion of the reaction is indicated by a distinct change, the solution becoming transparent cherry red, and its titer[4] with thiosulfate doubled. As it is advisable to have a slight excess of iodine, a small quantity of untreated solution should be retained and may be added in case of necessity.

N/10 sodium thiosulfate (hyposulfite) solution: 24.822 grams[5] of sodium thiosulfate, dissolved in water and made up to a liter.

Potassium bichromate solution: 3.8633 grams of dry C. P. potassium bichromate, free from sodium bichromate, dissolved in water and made up to a volume of 1,000 cubic centimeters at 20° C. This solution will keep almost indefinitely without changing, and is used for standardizing the thiosulfate solution. One hundred cubic centimeters of potassium bichromate will liberate 1 gram of iodine from a potassium iodide solution.

Potassium iodide solution: 165 grams of neutral potassium iodide, free from iodine and iodate, to 1,000 cubic centimeters of water. Iodate is said to be present frequently in commercial potassium iodide, and yields free iodine with hydrochloric acid.

Starch paste: 1 gram to 200 cubic centimeters of water. The indicator is prepared by boiling thoroughly, decanting and diluting the solution, and again boiling to insure a perfect paste free from solid particles.

Carbon tetrachloride: anhydrous[6] and free from oxidizable products.[7]

Standardizing the Thiosulfate. — Twenty-five cubic centimeters of potassium bichromate are accurately measured with a burette into a 300 cubic centimeter Erlenmeyer flask, and 10 cubic centimeters of potassium iodide and 5 cubic centimeters of concentrated hydrochloric acid added. Simultaneously with the addition of the acid, thiosulfate is run in until the brownish yellow color (iodine) has been largely destroyed; then 2 cubic centimeters of starch paste are added and the titration continued with repeated thorough shaking until the blue color has entirely disappeared, leaving a bright green solution. As four times the titration is equivalent to 1 gram of iodine, the iodine value of 1 cubic centimeter of thiosulfate can be readily calculated.

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[1] Ber. Deut. Chem. Gesell. 31, p. 750 (1898). Wijs' solution, with the same active reagent, iodine monochloride, has largely replaced that of Hubl on account of its far greater stability and more rapid absorption.

[2] The acid should be crystallized at 15° C. and the mother liquor discarded. The acid should not react with the bichromate test.

[3] Washed and dried by being passed through concentrated sulfuric acid. Gas sufficient for 4,000 cubic centimeters of iodine solution can be generated from 44.5 grams of sodium chloride, 55.5 grams of manganese dioxide, and 150 cubic centimeters of sulfuric acid (1 to 1).

[4] With the addition of potassium iodide as usual.

[5] Preferably 30 grams to 1,000 cubic centimeters of water.

[6] Dried over recently ignited sodium sulfate and distilled.

[7] Bichromate test.

In theory, 1 cubic centimeter N/10 $Na_2S_2O_35\ H_2O$ is equivalent to .012692 gram of iodine.

The following is the reaction: —

$$K_2Cr_2O_7+14\ HCl+6\ KI=2\ CrCl_3+8\ KCl+6I+7\ H_2O$$

$$6I : K_2Cr_2O_7 :: 1 : x$$

$$761.52 : 294.20 :: 1 : 0.38633 \text{ gram in 100 c.c.}$$

Wijs-Hubl Method.[1] — The amount of material to be taken for this determination varies inversely with its iodine number (see table). From 0.30 to 0.45 gram of drying or fish oil, 0.45 to 0.70 gram of a semidrying oil, 0.55 to 0.90 gram of a nondrying oil, or 0.60 to 2 grams of fat are brought into a 300 cubic centimeter Erlenmeyer flask, together with 20 cubic centimeters of carbon tetrachloride. After complete solution, 50 cubic centimeters of iodine solution, accurately measured with a burette, are added and the flask well stoppered and allowed to stand three to four hours, [2] with occasional shaking, in a refrigerator at a temperature below 10° C. A rapid bleaching of the solution indicates insufficient iodine. An excess equal to the amount absorbed is deemed necessary for the attainment of constant results. The cork stopper for the flask should be rolled until soft and pliable, and moistened with potassium iodide to prevent loss of iodine by volatilization. At the end of the absorption period, 50 cubic centimeters of cold, recently boiled distilled water and 10 cubic centimeters of potassium iodide are added to the contents of the flask, and the excess iodine titrated with sodium thiosulfate. The thiosulfate is run in gradually, with constant shaking, until the brownish yellow color of the solution has been largely destroyed; then 2 cubic centimeters of starch paste are added and the titration continued until the blue color has entirely disappeared. Towards the end of the reaction the flask should be stoppered and shaken vigorously, so that any iodine in the carbon tetrachloride will be taken up by the potassium iodide. The "bleached" condition should hold for a considerable time with the flask stoppered, although the blue color will develop again, due to the splitting off of iodine. Several blank determinations should be run with every series of tests. The difference between the titration of the blank and that of the excess iodine is the thiosulfate equivalent of the fat, which multiplied by the factor (obtained as described) and divided by the weight of fat taken gives the percentage of iodine absorbed.

Limit of error, 0.25 per cent.

Synopsis of Reaction. — Solution with carbon tetrachloride.

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[1] Original Hubl method. Dingler's Polytech. Jour., 253, p. 281.

[2] According to Lewkowitsch one-half hour is sufficient for all oils and fats having an iodine number below 100, one hour for semidrying oils and two to six hours for drying oils. — Analysis of Oils, Fats and Waxes, 1, p. 407, (1913).

Formation of chloro-iodo additive compounds with unsaturated acids and their glycerides.

Solution of excess iodine with potassium iodide and titration with thiosulfate, using starch paste as indicator.

$$2I + 2\ Na_2S_2O_3 = Na_2S_4O_6 + 2\ NaI$$

Amount of Material for Different Iodine Numbers.

[50 cubic centimeters of Wijs solution.]

IODINE NUMBER.	Grams of Material.	IODINE NUMBER.	Grams of Material.
200,	.32	100,	.64
195,	.33	95,	.67
190,	.34	90,	.71
185,	.34	85,	.75
180,	.35	80,	.79
175,	.36	75,	.85
170,	.38	70,	.91
165,	.39	65,	.98
160,	.40	60,	1.06
155,	.41	55,	1.16
150,	.43	50,	1.28
145,	.44	45,	1.42
140,	.46	40,	1.59
135,	.47	35,	1.82
130,	.49	30,	2.13[1]
125,	.51	25,	2.55[1]
120,	.53	20,	3.19[1]
115,	.55	15,	4.25[2]
110,	.58	10,	6.38[2]
105,	.61	5,	12.75[2]

[1] Take 2 grams.

[2] Take 2 grams and use 25 cubic centimeters of Wijs solution.

Supplementary Notes. — Unsaturated acids and their glycerides assimilate halogens with the formation of saturated compounds, and this property serves as a basis for their quantitative determination. Theoretically, chlorine, bromine, iodine, iodobromide or iodochloride may be employed for the purpose. The use of chlorine, however, is impractical, and bromine tends to form both substitution and addition products. Iodobromide (Hanus solution) has no advantage over iodochloride (Wijs solution) except ease of preparation; therefore the latter process, employing the same active agent (iodine monochloride), and agreeing closely with the original Hubl method under control conditions,[1] should be given preference, notwithstanding American practice to the contrary. Furthermore, Wijs has shown[2] that his solution yields practically theoretical results with a number of pure fatty acids. The solution is far more stable than that of Hubl and more rapid in its action.

The structure of unsaturated acids, particularly the position of the double bond in relation to the carboxyl group, influences the iodine absorption.[3] If the double bond is located at a considerable distance from the carboxyl the results are generally normal, but when relatively close together the iodine number is likely to be below theory, although lengthening the absorption period increases the results.

Wijs solution is said to yield high and variable results with cholesterol, and low results with rosin and rosin oils, increasing with the excess of iodine and the length of the absorption periods.

Olein is the principal unsaturated glyceride in nondrying oils and fats, linolin constitutes a considerable proportion of drying and semidrying oils and to some extent of nondrying oils and solid fats, and linolenin occurs in large amounts in all vegetable drying oils. Clupanodonin appears to be the characteristic constituent of fish, liver and blubber oils.

Linolic and linolenic acids and their glycerides absorb oxygen from the air at ordinary temperature and dry to a hard elastic layer, and to this property drying oils owe their value. On drying, such oils[4] absorb oxygen with oxidation of unsaturated acids, resulting in the formation of oxy-acids and corresponding loss of iodine number; polymerize with an increase in specific gravity and viscosity and additional loss in iodine number; partially dehydrate with formation of stearolactone; and liberate carbonic acid. These changes result in considerable molecular rearrangement. Oils that have been blown or boiled absorb less iodine. It is stated that for practical purposes drying oils should have an iodine number of at least 140, preferably 170 or higher, and nondrying oils of 90 or under. For purposes of classification Holde limits semidrying oils to a range of 95 to 130. Certain fish oils have a high iodine number and will absorb oxygen, but they do not dry to a hard layer. The fat of marine animals has a higher iodine number than that of terrestrial animals.

Calculated Data from the Iodine Number.

Theoretically, the unsaturated fatty acids belonging to the oleic, chaulmoogric and ricinoleic series absorb 2 atoms of the halogen; linolic and tariric series, 4 atoms; linolenic series, 6 atoms; clupanodonic series, 8 atoms, etc. The members of the chaulmoogric series are cyclic compounds, and contain only 1 pair of double-linked carbon atoms, while open chain acids of the same empirical formula would in most instances contain 2 pairs. Tariric acid contains triple-bond carbon atoms, and although it forms a tetrabromide, it generally absorbs only 1 or possibly 2 halogen atoms. The double-linked carbon atoms may be considered the ethylene type, and the triple-bonded an acetylene linkage. The glycerides act similarly to the free acids and absorb three times as many atoms (triglycerides).

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[1] Lewkowitsch, Analyst, 24, p. 259 (1899).

[2] Chem. Rev. Fett u. Harz Indus., 1899, p. 1.

[3] Lewkowitsch, Analysis of Oils, Fats and Waxes, 1, p. 400 (1913).

[4] Holde-Mueller, Examination of Hydrocarbon Oils, pp. 297–298 (1915).

In those cases where only one such acid or glyceride is present its percentage can be readily calculated from the iodine number by dividing by the theoretical absorption or by means of a factor.

$$\text{Oleic acid} = \frac{2\ \text{I}}{C_{17}H_{33}COOH} = \frac{2 \times 126.92}{282.272} = 0.89927$$

$$\text{Olein} = \frac{6\ \text{I}}{(C_{17}H_{33}COO)_3C_3H_5\ {}^{1}} = \frac{761.52}{884.832} = 0.86064$$

In a similar manner the following figures for theoretical absorption were deduced for the acids and glycerides enumerated below: —

	Acid.			Triglyceride.	
	Molecular Weight of Acid.	Theoretical Iodine Absorption.	Reciprocal.	Theoretical Iodine Absorption.	Reciprocal.
Oleic, ...	282.272	.89927	1.11201	.86064	1.16193
Erucic, ...	338.336	.75026	1.33287	.72308	1.38297
Linolic, ...	280.256	1.81149	.55203	1.73312	.57699
Linolenic, ...	278.240	2.73692	.36537	2.61770	.38201
Clupanodonic, ...	276.224	3.67586	.27205	3.51462	.28453
Ricinoleic, ...	298.272	.85104	1.17503	.81635	1.22496
Sitosterol, ...	386.368	.65699	1.52209	–	–
Cholesterol, ...	386.368	.65699	1.52209	–	–

Where there are two unsaturated acids (or glycerides) present (x and y) of known iodine absorption (c and d), if the percentage of the mixture (P) and the iodine number (W) of the fat have been determined, the per cent. of each acid (or glyceride) can be calculated by formula.

$$x + y = P$$

$$cx + dy = .01\ W\ {}^{2}$$

$$x = \frac{.01\ W - dP}{c - d}$$

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[1] $3(C_{17}H_{33}COOH) + C_3H_2$ or $3m + 38.016$.

[2] The factor 0.01 converts the iodine number to the same basis as the figures for theoretical absorption stated in the previous table.

ACETYL NUMBER.

The acetyl number indicates the number of milligrams of potassium hydroxide required to combine with the acetyl[1] absorbed by 1 gram of an oil, fat or wax on acetylation.[2]

Reagents. — Acetic anhydride: Kahlbaum's.

Ceresine: pure white, filtered.

Alcohol: redistilled, free from acids and aldehydes.

Alcoholic potash: 50 cubic centimeters of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of alcohol. The solution should be allowed to stand at least twenty-four hours and filtered immediately before use.

N/2 hydrochloric acid.

Phenolphthalein solution: 1 gram to 100 cubic centimeters of alcohol, neutralized.

Cotton blue 6B solution: 2 grams to 100 cubic centimeters of alcohol. The indicator should be boiled in a flask under a reflux condenser for two hours and then filtered.

Method. — Into a 300 cubic centimeter Erlenmeyer flask are brought 5 grams of fat, together with 10 cubic centimeters of acetic anhydride. The flask is connected with a spiral or other form of reflux condenser and heated in a boiling water bath (immersed in the water) for from one to one and one-half hours. Longer heating yields higher results, but is accompanied by partial decomposition of the fat with formation of aldehydes or other bodies that give a reddish color with caustic alkali. After acetylating, the spiral is removed from the flask and sufficient ceresine added to form a solid disk with the fat when chilled in cold water. The amount of ceresine required will vary with the consistency of the product under examination. For butter fat 0.5 gram is ample; for softer fats and oils, rather more; and for harder fats, less. With the flask still in the water bath, 150 cubic centimeters of boiling water are added with as little disturbance of the fat layer as possible. The flask is then removed and the contents rotated vigorously to dissolve occluded acetic acid. The flask is immersed in cold water to solidify the ceresine fat, after which the solution is decanted through a dense, 12.5 centimeter filter, care being taken not to break the insoluble cake. Another 150 cubic centimeters of boiling water is added, thoroughly agitated, heated a few minutes on the bath, cooled and decanted, the process being repeated until the final filtrate gives a decided color with two or three drops of N/10 alkali, using phenolphthalein as indicator (about six times). Prolonged washing is likely to cause some hydrolysis of the acetylated product.

The filter and inverted flask containing the cake of ceresine fat are allowed to drain in a cool place until practically dry. The small particles adhering to the filter are then scraped into the flask, the inner portion of the filter paper extracted in a small beaker with three successive 20 cubic centimeter portions of boiling alcohol, and poured into the flask; then 50 cubic centimeters of alcoholic potash, accurately measured with a burette, and several glass beads are added. The flask is connected with a spiral or other form of reflux condenser, and the solution boiled on a water bath until saponification is complete, — about sixty minutes. The flask is placed in a water bath at 60° C., and the solution, after cooling to that temperature, titrated with N/2 hydrochloric acid, using 1 cubic centimeter of phenolphthalein or cotton blue as indicator. Cotton blue offers certain advantages in the case of solutions that develop a reddish color with caustic alkali. The alcoholic mixture is again brought to boil to free any alkali occluded in the ceresine, and retitered if necessary. Several blank determinations should be run with every series of tests, under precisely similar conditions as to time and treatment except that the ceresine may be omitted. However, every lot of ceresine must be tested. It should be free from soluble matter and not assimilate any alkali on saponification. The difference between the titration of the blank and that of the excess alkali in the test is the acid equivalent of the fat after acetylation, which should be calculated to milligrams of potassium hydroxide for 1 gram of fat.

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[1] On saponification the acetyl hydrolyzes to acetic acid and combines with the alkali.

[2] Benedikt and Ulzer, and Lewkowitsch report on the basis of the acetylated product.

One cubic centimeter of N/2 acid is equivalent to 28.054 milligrams of potassium hydroxide.

The difference between the saponification number of the fat before and after acetylation is the acetyl number. In case the original fat contains *free soluble* acids their titer should be determined and proper correction made for the same.

Limit of error, 0.50 milligram.

Synopsis of Reaction. — Acetylation of glycerides of monohydroxy and dihydroxy acids, monoglycerides and diglycerides and free alcohols. (See formulas.)

Saponification of the acetylated product. (See formulas.)

Saponification of the original or unacetylated product.

Titration of excess alkali.

Acetyl number by difference.

Glycerides of Monohydroxy and Dihydroxy Acids.

Acetylation.

$$\underset{\text{triglyceride of monohydroxy acid}}{(R\,.\,OH\,.\,COO)_3C_3H_5} + 3\,\underset{\text{acetic anhydride}}{(CH_3CO)_2O} = \underset{\text{acetylated glyceride}}{(R\,.\,OCH_3CO\,.\,COO)_3C_3H_5} + 3\,\underset{\text{acetic acid}}{CH_3COOH}$$

Example: Ricinolein $(C_{17}H_{32}\,.\,OH\,.\,COO)_3C_3H_5$

Saponification.

$$\underset{\text{acetylated glyceride}}{(R\,.\,OCH_3CO\,.\,COO)_3C_3H_5} + 6\,\underset{\text{alkali}}{KOH}$$

$$= 3\,\underset{\text{potassium salt of hydroxy acid}}{R\,.\,OH\,.\,COOK} + 3\,\underset{\text{potassium acetate}}{CH_3COOK} + \underset{\text{glycerol}}{C_3H_5(OH)_3}$$

$$\underset{\text{triglyceride of dihydroxy acid}}{[R(OH)_2COO]_3C_3H_5} + (CH_3CO)_2O = \underset{\text{acetylated glyceride}}{[R(OCH_3CO)_2COO]_3C_3H_5} + H_2O$$

Example: Dihydroxystearin $[C_{17}H_{33}(OH)_2COO]_3C_3H_5$

$$[R(OCH_3CO)_2COO]_3C_3H_5 + 9\,KOH = 3\,R(OH)_2COOK + 6\,CH_3COOK + C_3H_5(OH)_3$$

Monoglycerides and Diglycerides.

$$\underset{\text{monoglyceride}}{(RCOO)C_3H_5(OH)_2} + (CH_3CO)_2O = \underset{\text{diaceto-glyceride}}{(RCOO)\;(CH_3COO)_2C_3H_5} + H_2O$$

$$(RCOO)\;(CH_3COO)_2C_3H_5 + 3\,KOH = RCOOK + 2\,CH_3COOK + C_3H_5(OH)_3$$

$$\underset{\text{diglyceride}}{(RCOO)_2C_3H_5(OH)} + (CH_3CO)_2O = \underset{\text{monaceto-glyceride}}{(RCOO)_2(CH_3COO)C_3H_5} + CH_3COOH$$

$$(RCOO)_2(CH_3COO)C_3H_5 + 3\,KOH = 2\,RCOOK + CH_3COOK + C_3H_5(OH)_3$$

Free Alcohols.

$$\underset{\text{monobasic alcohol}}{ROH} + (CH_3CO)_2O = \underset{\text{acetate of alcohol}}{CH_3COOR} + CH_3COOH$$

$$CH_3COOR + KOH = ROH + CH_3COOK$$

Examples: Sitosterol, cholesterol, $C_{27}H_{45}OH$

Considerable variation is possible in writing the above formulas which, at best, poorly express the structure. In some instances the reaction is indicated at some sacrifice of form.

Calculated Data from the Acetyl Number.

The acetyl number (c) serves to measure the amount of hydroxy compounds in an oil, fat or wax, and in case only one such compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount (H) can be readily calculated by the following formula: —

$$H = \frac{cm}{56108\,d}$$

The derivation of the formula is comparatively simple. The theoretical acetyl number of a compound containing d hydroxyl groups is: —

$$\frac{56108\,d}{m}$$

The amount of such a compound in an oil, fat or wax is therefore —

$$\frac{c}{\frac{56108\,d}{m}} \text{ or } \frac{cm}{56108\,d}$$

The same results may be calculated more easily from the following table dividing the determined acetyl number by the theoretical acetyl number, or multiplying by its reciprocal: —

Acetyl Number on Original Product.

NAME.	Formula.	Molecular Weight.	Saponification Number.	Theoretical Acetyl Number.	Reciprocal.
Glycerides.					
Ricinolein, . .	$(C_{17}H_{32}.OH.COO)_3C_3H_5$	932.832	180.444	180.444	.0055419
Dihydroxystearin, .	$(C_{17}H_{33}(OH)_2COO)_3C_3H_5$	986.880	170.562	341.124	.0029315
Monoglycerides.					
Monopalmitin, . .	$(C_{15}H_{31}COO)C_3H_5(OH)_2$	330.304	169.868	339.736	.0029435
Monostearin, . .	$(C_{17}H_{35}COO)C_3H_5(OH)_2$	358.336	156.579	313.159	.0031933
Monolein, . . .	$(C_{17}H_{33}COO)C_3H_5(OH)_2$	356.320	157.465	314.930	.0031753
Diglycerides.					
Dipalmitin, . .	$(C_{15}H_{31}COO)_2C_3H_5(OH)$	568.544	197.374	98.687	.0101330
Distearin, . . .	$(C_{17}H_{35}COO)_2C_3H_5(OH)$	624.608	179.658	89.829	.0111323
Diolein, . . .	$(C_{17}H_{33}COO)_2C_3H_5(OH)$	620.576	180.826	90.413	.0110604
Hydroxy Acids.					
Ricinoleic, . .	$C_{17}H_{32}.OH.COOH$	298.272	188.110	188.110	.0053160
Dihydroxystearic, .	$C_{17}H_{33}(OH)_2COOH$	316.288	177.395	354.791	.0028186
Free Alcohols.					
Sitosterol, . . .	$C_{27}H_{45}OH$	386.368	–	145.219	.0068862
Cholesterol, . .	$C_{27}H_{45}OH$	386.368	–	145.219	.0068862

Gravimetric Process.[1] — After acetylating, a gravimetric process for acetyl number may be conducted in a manner similar to that for the quantitative determination of insoluble fatty acids, observing all the precautions therein noted as to ceresine, washing, drying, weighing, etc.

This modification is apparently rather more difficult, tedious and subject to error than the saponification or volumetric process. An inaccuracy, due to a deficiency in weight arising from the dehydration of free fatty acids by acetic anhydride during acetylation, is probably unavoidable, although of little consequence where the amount of free acids is relatively small.

The acetyl number (a) is calculated from the increase in weight (i) by the following formula: —

$$a = \frac{56108\ i}{42.016} \quad \text{or} \quad 1335.39604\ i$$

In case only one hydroxy compound of known molecular weight (m) and number of hydroxyls (d) is present, its amount can be calculated from the increase in weight (i) of the oil, fat or wax on acetylating. The theoretical increase for a hydroxy compound is —

$$\frac{42.016\ d}{m}$$

The amount (H) of such a compound in an oil, fat or wax is, therefore —

$$H = \frac{i}{\frac{42.016\ d}{m}} \quad \text{or} \quad \frac{im}{42.016\ d}$$

Molecular Weight of Hydroxy Compounds. — The molecular weight of the hydroxy compounds can be calculated from the weight (w) of fat taken and the increase (i) on acetylating, provided the number (d) of hydroxyls in the molecule is known: —

$$w : w+i :: m : m+42.016\ d$$

$$m = \frac{42.016\ dw}{i}$$

The formation of anhydrides during the acetylating process will affect the accuracy of these calculations.

The computation of the amount of hydroxy compounds by the gravimetric process is greatly facilitated by use of the following table: —

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[1] Has not received sufficient study in this laboratory to warrant positive statements, but is similar to the methods described by Lewkowitsch (*loc. cit.*) 1, pp. 451–453, 578–580 (1913).

Acetyl Gravimetric Process on Original Product.

NAME.	Molecular Weight.	Molecular Weight after acetylating.	Theoretical Increase in Weight per Gram on acetylating.[1]	Reciprocal.
Glycerides.				
Ricinolein,	932.832	1058.880	.135124	7.40061
Dihydroxystearin,	986.880	1238.976	.255447	3.91471
Monoglycerides.				
Monopalmitin,	330.304	414.336	.254408	3.93069
Monostearin,	358.336	442.368	.234506	4.26428
Monolein,	356.320	440.352	.235833	4.24029
Diglycerides.				
Dipalmitin,	568.544	610.560	.073901	13.53162
Distearin,	624.608	666.624	.067268	14.86591
Diolein,	620.576	662.592	.067705	14.76996
Hydroxy Acids.				
Ricinoleic,	298.272	340.288	.140865	7.09900
Dihydroxystearic,	316.288	400.320	.265682	3.76390
Free Alcohols.				
Sitosterol,	386.368	428.384	.108746	9.19574
Cholesterol,	386.368	428.384	.108746	9.19574

[1] Acetyl number = 1335.39604 i.

Supplementary Notes. — The various hydroxy compounds that occur in oils, fats and waxes form derivatives on heating with acetic anhydride, the acetyl radical displacing the hydrogen of the alcoholic hydroxyl groups. This property serves as the basis of analytical methods for the quantitative determination of monohydroxy and dihydroxy acids and their glycerides, monoglycerides and diglycerides, and free alcohols.

Glycerides of hydroxy acids are a natural constituent of certain oils and fats, although they do not appear to be very widely distributed in any considerable amount. Castor oil, composed largely of ricinolein, is an excellent illustration. Hydroxy acids probably occur more frequently as the result of oxidation of unsaturated acids. Oleic acid has been shown repeatedly to be comparatively unstable. By the assimilation of oxygen and water it may be converted into dihydroxystearic acid, a saturated compound.

$$C_{17}H_{33}COOH + H_2O + O = C_{17}H_{33}(OH)_2COOH$$

Whether the oxidation takes place in the glycerides or in the fatty acids after hydrolysis is uncertain, although the latter appears the more probable supposition.

Monoglycerides and diglycerides result from the hydrolysis of triglycerides, and free fatty acids condition their presence; the absence of free fatty acids in a commercial product, however, does not necessarily preclude the presence of monoglycerides and diglycerides.

Solid alcohols of the cyclic series (sterols) occur in oils and fats both in combination as esters and as free alcohols.[1] The amount of sitosterol or cholesterol is generally small, often inappreciable, and is indicated approximately by the unsaponifiable matter which it characterizes. Alcohols of the ethane and other series, free and in combination, compose a considerable proportion of waxes.

Oils and fats, therefore, may contain glycerides of monohydroxy and dihydroxy acids, possibly free hydroxy acids, monoglycerides and diglycerides and free alcohols; and the insoluble acids, separated from the oils and fats, may contain monohydroxy and dihydroxy acids and free alcohols. A portion, at least, of the free alcohols found in the insoluble acids probably occurred in the fat as esters. With the exclusion of the natural glycerides of hydroxy acids and a small amount of free alcohols the acetyl number of many oils and fats may be deemed an index of quality, and when considered in conjunction with the acid and iodine numbers may serve to measure (more or less imperfectly, to be sure) the amount of hydrolysis and of oxidation the product has undergone. To differentiate between products of hydrolysis and of oxidation the percentage of insoluble acids and their acetyl number should also be determined.

Of the oils, fats and waxes with an appreciable content of hydroxy compounds[2] might be mentioned candle nut oil, safflower oil, rape oil, peanut oil, olive oil, elderberry oil, Japanese sardine oil, skate liver oil, shark liver oil, seal oil, horses' foot oil, palm oil, bone fat and beeswax, having acetyl numbers between 10 and 20; neat's-foot oil, Japan wax, carnauba wax and wool wax, having acetyl numbers ranging from 25 to nearly 60; and castor oil, having an acetyl number of about 170.

UNSAPONIFIABLE MATTER.

The unsaponifiable matter indicates the percentage of all those components of an oil, fat or wax which on boiling with potassium hydroxide do not form water-soluble compounds.

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[1] See numerous references: Abderhalden, Physiol. Chem. (1908); Hammarsten, Physiol. Chem. (1911); Leathes, The Fats (1910).

[2] Lewkowitsch, Analysis of Oils, Fats and Waxes, 1., pp. 434–435 (1913).

Reagents. — Alcohol: redistilled, free from acids and aldehydes.

Alcoholic potash solution: 50 cubic centimeters of a saturated solution of potassium hydroxide, free from carbonate, to 1,000 cubic centimeters of alcohol. The alkali should be added to the alcohol slowly, with agitation, in order to prevent any appreciable rise in temperature.

Methyl alcohol: redistilled, free from acids and aldehydes. The alcohol is prepared from Columbian spirits by distillation over caustic lime.

Potassium carbonate: anhydrous, free from caustic alkali.

Ethyl ether:[1] anhydrous, free from alcohol and residue. The ether should be allowed to stand over metallic sodium until evolution of gas ceases, and then redistilled.

Method.[2] — Five grams of fat are brought into a 300 cubic centimeter Erlenmeyer flask, together with 75 cubic centimeters of alcoholic potash and 25 cubic centimeters of alcohol. The flask is connected with a spiral or other form of reflux condenser and the solution boiled on a water bath with occasional rotating of the contents until saponification is complete, — about sixty minutes. The solution is transferred to a 250 cubic centimeter Griffin beaker and the flask rinsed several times with hot alcohol. The alcohol is evaporated in a water bath (with the beaker immersed in the water) at a gradually increasing temperature. Several 25 cubic centimeter portions of methyl alcohol are added and evaporated to insure *complete dryness.* Careful heating is necessary to avoid spattering.

The dry residue is pulverized in a mortar with 25 grams of anhydrous potassium carbonate, dried two hours at 100° C., transferred to an S. & S. extraction thimble, 33 by 80 millimeters, extracted two to three hours with anhydrous ether in a continuous extracter (see Fig. 4), and the ether expelled as usual. Notwithstanding the precautions mentioned, moisture may be absorbed during the process and vitiate the ether extract with a small amount of water-soluble compounds. To eliminate this error the air-dry extract is washed with several 25 cubic centimeter portions of water at room temperature, and decanted on an ether-extracted filter which is air dried, and extracted with ether, using the same flask as before. The purified extract is dried from 1 to 1.5 hours in an oven at 100° C. and considered unsaponifiable matter.

In most oils and fats there is a comparatively small amount of unsaponifiable matter, but greater accuracy is not insured by taking a larger amount of material (say 10 grams), for the reason that the greater the bulk of soap the more difficult the manipulation.

Seventy-five cubic centimeters of alcoholic potash instead of 50 cubic centimeters, the usual quantity, are employed to prevent any reversible reaction to which there appears to be a tendency on evaporating. One hundred cubic centimeters, however, destroy a portion of the sterols.

Anhydrous potassium carbonate proved a more efficient dehydrating agent than the corresponding sodium salt.

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[1] Commercial ether of the U. S. P. grade is unfit for the purpose, and the "distilled over sodium" grade is often unreliable, due to its hygroscopic properties.

[2] Not applicable for volatile hydrocarbons or ethereal oils.

Limit of error, 0.05 per cent.

Synopsis of Reaction. — Saponification of the fat with alcoholic potash.

Evaporation of the alcohol and dehydration of the soap.

Extraction of the unsaponifiable matter with ethyl ether.

Purification of the extract.

Supplementary Notes. — In terms of the definition, the components of unsaponifiable matter do not form water-soluble compounds on boiling with potassium hydroxide. They are largely soluble, however, in the soap solution, which is a factor to be noted in their separation by ethyl ether from water or dilute alcoholic solutions. Furthermore, water hydrolyzes neutral soaps, and alcoholic solutions containing less than 50 per cent. alcohol are unreliable for the same reason, as described under "Acid Number." Soaps are soluble in moist ether. The extraction of un-

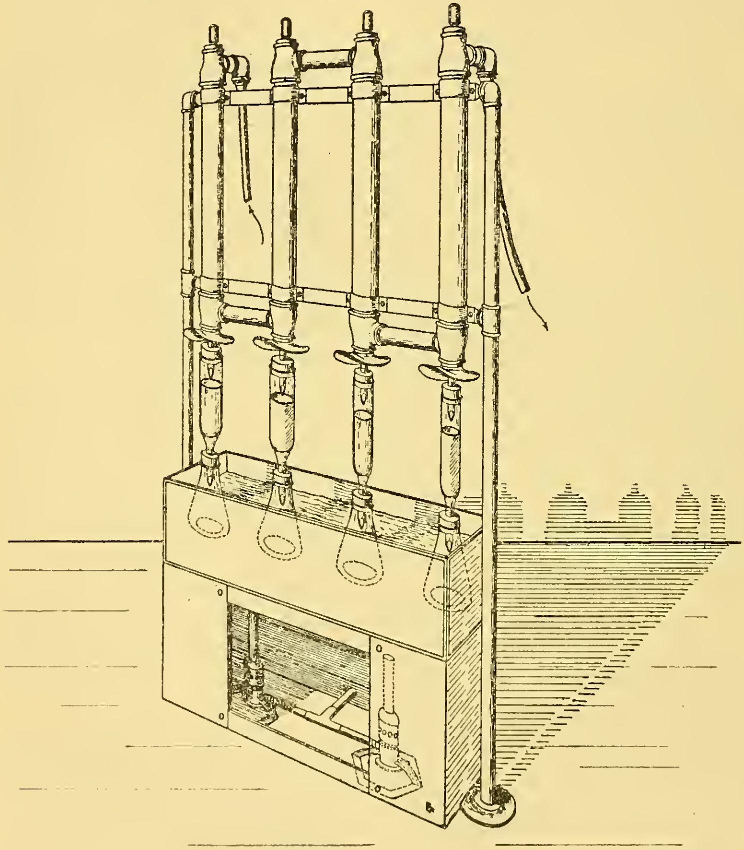

FIG. 4. — Ether extraction apparatus employed in the determination of unsaponifiable matter.

saponifiable matter in the dry state, therefore, promises more trustworthy results, although it is a more lengthy process and not entirely free from criticism.

The unsaponifiable matter of oils and fats consists principally of the solid alcohols of the cyclic or aromatic series, the so-called sterols (sitosterol, stigmasterol, brassicasterol and cholesterol). In some products occur alcohols of the ethane series (ceryl and melissyl) and hydrocarbons, also small amounts of coloring matter, resinous substances, ethereal oils, nitrogenous bodies (lecithin, mucilaginous matter), etc.

Sitosterol is the characteristic concomitant of vegetable oils and fats, and cholesterol of animal. The former alcohol is sometimes accompanied by stigmasterol or brassicasterol. Stigmasterol has been found in soy bean oil, calabar bean oil and rape oil.

Ceryl and melissyl alcohols are the only members of the ethane series that appear to have been identified.

Hydrocarbons have been reported in buckthorn oil, kosam seed oil, parsley seed oil, cantharides oil, chrysalis oil, laurel oil and cacao butter. The unsaponifiable matter of laurel oil has a high iodine number. The chromogenic bodies give the color reactions in identification tests of cottonseed, sesame, liver oils, etc. Ethereal oils occur in nutmeg butter.

Remnants of vegetable or animal tissue are purely adventitious substances, and should always be excluded.

Among extraneous substances that may appear in the unsaponifiable matter are mineral oils (petrolatum and shale oils), tar oils (neutral coal oils), paraffin, ceresine, rosin oils, etc. They occur in the oils and fats as adulterants.

The amount of unsaponifiable matter in oils and fats varies from a trace to several per cent. Corn, cottonseed and sesame oils show over 1 per cent. in some instances, while rape, peanut and olive oils appear to average less. Fish, liver and blubber oils, such as herring, cramp fish, cod liver, shark liver, whale and porpoise oils, sometimes contain 10 or even 20 per cent. Old rancid fats yield larger amounts than fresh fats.

The unsaponifiable matter of waxes includes alcohols of the ethane series (cetyl, ceryl, melissyl, etc.), of the cyclic series (sitosterol, cholesterol and isocholesterol) and of several other series seemingly less prominent, and of hydrocarbons. The alcohols in the natural product evidently occur both free and in combination with fatty acids as esters. They are mostly monatomic, the more common belonging to the ethane series.

Sitosterol is found in vegetable flax wax, and cholesterol and isocholesterol in wool wax and probably in beeswax.

Hydrocarbons constitute an appreciable amount in waxes, particularly in the case of the solid waxes.

Adulterants similar to those of oils and fats may be expected.

The unsaponifiable matter in liquid waxes varies from 31 to 43 per cent., and in solid waxes from 43 to 55 per cent.

Sterols.

The sterols indicate the percentage of cyclic alcohols in an oil, fat or wax.

Reagents. — Ninety-five per cent. alcohol:[1] redistilled, free from acids and aldehydes.

Digitonin solution: 1 gram to 100 cubic centimeters of 90 per cent. alcohol.

Ethyl ether.

Windaus Method.[2] — The unsaponifiable matter is dissolved in boiling 95 per cent. alcohol in the proportion of 1 to 50, and the sterols precipitated with an excess of hot digitonin solution. After standing overnight at room temperature, the precipitate is brought into a tared Gooch crucible with 95 per cent. alcohol, washed with alcohol and then with ether, dried in an oven at 100° C., and weighed as digitonin-sterol. Digitonin unites with the sterols, molecule for molecule, to form an addition product without loss.

From the weight obtained the percentage of sterols can be calculated by the factor 0.2431.

Limit of error, 0.05 per cent.

Synopsis of Reaction. — Solution of the unsaponifiable matter in hot alcohol.

Precipitation of the sterols with digitonin.

$$C_{27}H_{45}OH + C_{55}H_{94}O_{28} = C_{82}H_{140}O_{29}$$

Filtration and weight of digitonin-sterol.

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[1] See "Reagents" under "Saponification Number."

[2] Ztschr. Phys. Chem., 65, pp. 110–117 (1910).

DEPARTMENT OF MICROBIOLOGY.

PART I.

THE RELATION OF HYDROGEN ION CONCENTRATION OF MEDIA TO THE PROTEOLYTIC ACTIVITY OF BACILLUS SUBTILIS.

BY ARAO ITANO.

INTRODUCTION.

Since the physico-chemical methods were introduced into the field of biology, the influence of ions, such as Na, Ca, Cl, H, upon the vital processes has been increasingly recognized by biologists. This influence is manifested in many phases of biology. In this investigation the relation of the hydrogen and hydroxyl ion concentration, or "true acidity" and "true alkalinity"[1] of media, to the proteolytic activity of *B. subtilis* has been studied.

The importance of the effect of hydrogen ion concentration of media upon the bacterial growth has been well known to bacteriologists, but it has been impossible to determine the so-called "true reaction." With the introduction of physico-chemical methods, progress toward the measurement of absolute reaction has been made.

So far as the author knows, Brünn,[2] in 1913, was the first to undertake the investigation of the disinfecting property of acids upon *B. coli* and *B. typhosus*. He found that the hydrogen ion concentrations 2×10^{-5} and 1×10^{-5} at 37° C. for twenty-four hours have a corresponding germicidal effect. Since then, several other investigators have performed similar experiments with the hydrogen ion concentration, employing several species of bacteria for their test. The author fails, however, to find that any investigation in the light of hydrogen ion concentration has been conducted on the subject of proteolysis instigated by bacteria. Brünn's experiment illustrates the influence of hydrogen ion concentration upon bacterial life. In other biologic fields, however, considerable work has been done to point out the importance of such an experiment on the several physiologic processes. Sörensen[1] studied extensively the influence of different hydrogen ion concentrations upon enzymes, and concluded that enzymatic action can be controlled by adjusting the reaction of media. In the medical world the phenomena of "acid intoxication" in different forms have suggested the importance of the study of "true acidity" of blood and urine. Michaelis[2] pointed out the clinical importance of the "true reaction" of the blood. Henderson and Palmer[3] have demonstrated the clinical value of "true reaction" in its relation to the urine. Their results are not specific unless they are to indicate the normal and abnormal condition of the body.

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[1] "True acidity" and "true alkalinity" are the common terms adopted by S. P. L. Sörensen to express the H and OH ion concentration.

[2] Uber das Desinfektionsvermögen der Säuren. Diss., Berlin, 1913.

In agriculture, several perplexing problems have presented themselves in which the hydrogen ion concentration is involved. Such subjects as the acidity of soil, of plants, of milk and of many other substances in both the organic and inorganic world are now the problems of agricultural investigations. Since this acidity is caused only by the dissociated hydrogen ions, regardless of the exact nature of the chemical compound, a better understanding of the "true reaction" is evidently desirable.

The importance of proteolysis in decomposition of proteins is so well understood that further consideration is unnecessary, except a mention of its association with dairy, food and soil studies. So much weight is attached to it that it has become fairly basic to all scientific advancement. In order to make the study yield easily to confirmation, *B. subtilis* has been selected because of its well-known characteristics for identity. This organism makes a good starting point from which the proteolysis of other organisms may be investigated and paralleled.

While we recognize that hydrogen ion concentration is only one factor in proteolysis, the significance attached to it must lend considerable force to its solution. The progress has been extremely slow awaiting the development of the chemistry of proteins. The author is familiar only with Sörensen's formol titration method[4] as the one serving to secure the additional knowledge of proteolysis. So far as it has been applicable it seems very satisfactory.

Classification in microbiology seems at present to be based upon the morphology and biometric characters. There is a subcurrent of feeling that physiologic properties are so variable that they are not reliable. This may not hold true, however, if it becomes possible to use more exact physiologic methods, for through them may be found those delicate differences which are more or less constant and recognized in the metabolism of higher organisms. Then, too, if morphology is a mere expression of physiology and the molecular mechanism of organisms, there is greater reason for looking more deeply into the relation of hydrogen ion concentration as manifested in different species and varieties.

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[1] Ergebnisse d. Physiologie, 12, 449 (1912).

[2] Die Wasserstoffionenkonzentration, 85, 1914.

[3] Jour. of Biol. Chem., V. 13, No. 4, Jan., 1913.

[4] E. Abderhalden. Handb. d. Biochem. Arbeitmethoden, Bd. 6, S. 262, 1912; Comptes rendus du Laboratoire de Carlsberg, 7, 1, 1907; Biochem. Zeitschr., 7, 43, 1907.

REVIEW OF PREVIOUS INVESTIGATIONS.

The influence of acidity and alkalinity upon biologic processes has been investigated by many who are engaged in the study of general physiology, as has been intimated in the introduction. In physiologic investigation of bacterial life, Kisch's method [1] was generally employed previous to the introduction of the physico-chemical method. Sieber [2] investigated the antiseptic value (minimum dose) of different acids upon various bacteria. Schlüter [3] found that *M. prodigiosus* grows very well in lactic acid 0.1 per cent., but not higher. Carbett [4] showed that *Bacterium diphtheriæ* is able to grow in higher acidity than *M. prodigiosus.* Proskauer and Beck [5] pointed out that *Bacterium tuberculosis* lives in higher acidity than the other organisms mentioned above.

Similar experiments were carried out to determine the influence of alkalinity. Kitasato [6] demonstrated that *B. typhosus* is killed by 0.1 to 0.14 per cent. KOH and *Vibrio choleræ* by 0.18 per cent. KOH solution. Liborius [7] experimented with potassium carbonate and discovered that most bacteria withstood 0.5 per cent., *B. typhosus* 0.8 per cent. and *Vibrio choleræ asiaticæ* 1.0 per cent. K_2CO_3 solution. Deeleman [8] ascertained that the optimum alkalinity for most bacteria is approximately between 0.34 and 1.7 per cent. normal NaOH.

Again literature cites many instances to show the influence of acidity and alkalinity upon the bacterial proteolytic enzyme. Wood, [9] studying proteolytic enzymes from different bacteria, found that these enzymes varied greatly in their power of resisting acid media, and noticed also that the bacteria themselves showed a varying susceptibility to acid, corresponding exactly to their enzymes. Fermi [10] recognized that the enzymes of several bacteria, *M. prodigiosus, B. pyocyaneus, Bact. anthracis* and others, work most advantageously in faintly alkaline solution, although they attack a solution of gelatin containing 0.5 per cent. HCl.

Besides these purely physiologic experiments, numerous references may be found in literature which deal with the reaction of culture media upon the morphology and general physiology of bacteria. Fuller [11] reviewed quite completely the literature of this subject which is treated in his publication. There is indicated a marked influence of media-reaction upon pigment formation, and even upon the morphology, etc., of different bacteria. According to Fuller's publication, moreover, all these investigations were based on the reaction of media which were adjusted by either Schültz's[1] or Fuller's[2] scale, or the so-called "scale of reaction" which will be discussed later. Considering these investigations in the light of the physico-chemical methods of the present day, the influence of the so-called "true acidity" or "true alkalinity" on bacterial life is not sufficiently known, because Kisch's method, as well as others which will be presented in detail later, is not applicable.

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[1] Kisch, B. Biochem. Zeitschr., 40, 152, 1912.

[2] Jour. Prakt. Chem., 19, 433, 1879.

[3] Zeitschr. Bakt., 11, 589, 1892.

[4] Ann. Inst. Pasteur, 11, 251, 1897.

[5] Zeitschr. Hyg., 18, 128, 1894.

[6] Zeitschr. Hyg., 3, 418, 1888.

[7] Ebenda, 2, 1896.

[8] Arb. kais. Gesundh. Amt., 13, III, 1897.

[9] Laboratory Reports, Roy. College Phys., Edinburgh, V, II.

[10] Centralbl. f. Bakt., Bd. 16, 176, 1906.

[11] Jour. Amer. Pub. Health Assn., 1895, 20, 381.

Recently, with the development of a physico-chemical method, it has become possible to measure the hydrogen ion concentration and also to apply it in the field of biologic investigation. Of late, as already related, several biochemists and biologists have employed the method in various lines of work, such as hydrogen ion concentration in blood, urine, wine, milk, water, etc.[3] As yet, references on the direct bacteriological work are comparatively rare. Beside Brünn's investigation,[4] which was mentioned in the introduction, Michaelis and Marcola[5] investigated the acid production by *B. coli*, and found that it produces lactic acid in alkaline lactose nutrient broth until it reaches a hydrogen ion concentration designated as $P_H = 5$, when the action ceases. Clark's recent investigations[6] concerning the reaction of bacteriologic culture media, by both old (titrimetric) and new (hydrogen electrode) methods, will be discussed later, together with the physiologic importance of hydrogen ion concentration. Clark pointed out the fallacies of the titrimetric method, and noted the advisability of substituting a colorimetric method. He experimented also with several different enzymes, such as trypsin, maltase, urease and others, and marked the approximate range of hydrogen ion concentration and degree of their activity. Clark and Lub[7] employed the hydrogen electrode to determine the change in hydrogen ion concentrations in various cultures of the colon-ærogenes family, and established the correlation between the gas ratio and hydrogen ion concentration in the culture medium. They recommend the use of indicators, *i.e.*, paranitrophenol or methyl red, for differentiation of bacteria of this family.

These investigations added some knowledge regarding the influence of hydrogen ion concentration upon the bacterial life. This investigation deals more comprehensively with the influence of hydrogen ion concentration on bacterial life, together with other matters.

The proteolytic activity of bacteria has attracted much attention from bacteriologists. Many observations and experiments have been carried out since gelatin has been used as a culture medium. In 1886 Bitter[8] discovered that microörganisms subjected to a temperature higher than thermal death point retain the ability to liquefy gelatin, although the microörganisms themselves are killed. Hankin[1] showed that an extract made from *Bact. anthracis* contains an enzyme which is capable of forming albumoses from fibrin. Sirotinin[1] has proved that certain bacteria produce exo-enzymes. Brunton and MacFadyen[2] found that the secretion of certain enzymes by a particular bacterium is influenced by the constituents of the media in which it is cultivated, and also that its activity is governed by the acids and alkalis present. Wood[1] extracted enzymes from the culture media in which several known bacteria were cultivated. Thus far these workers have dealt with the proteolytic activity of bacteria qualitatively, and have noted some of the operating influences. It was Fermi who attempted to determine quantitatively the proteolysis caused by different bacteria. He measured the amount and rapidity of gelatin solution. Besides gelatin, Fermi[3] experimented with other protein substances, such as fibrin, egg albumin, coagulated serum-albumin, using the enzymes secreted by various bacteria; but he found that the greatest activity in proteolysis is secured in gelatin. His investigation is not tenable because room temperatures fluctuate widely and cannot furnish exact conditions of growth. The influence of the liquefying of gelatin by heat upon proteolysis must make the results variable. There is an optimum temperature for proteolysis as well as for the growth of microörganisms; consequently, only definite temperatures can be used for its study. Eijkmann[4] employed milk agar in the study of different microorganisms. The results obtained, however, were only approximate. Later, Abderhalden and Koelker[5] and others introduced the polariscope to determine the degree of proteolysis; but this method is not well adapted to general work on account of turbidity of growth and the slight degree of polarization. With the development of protein chemistry it became possible to ascertain quantitatively the cleavage products. Rosenthal and Patai[6] investigated the proteolytic activity of streptococci, staphylococci and the colon group by the formol titration method of Sörensen, which is yet to be discussed.

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[1] Centralbl. f. Bakt., O, 1891, 10, 52.
[2] Jour. Amer. Pub. Health Assn., 1895, 20, 381.
[3] Michaelis, L. Die Wasserstoffionenkonzentration, 84, 1914, Berlin.
[4] Uber das Desinfectionsvermögen der Säuren. Diss., Berlin, 1913.
[5] Zeitschr. f. Immunitätsforschung, 1912, 14, 170.
[6] Jour. of Infect. Diseases, V. 17, No. 1, July, 1915, 160–173.
[7] Jour. of Infect. Diseases, V. 17, No. 1, July, 1915, 109–136.
[8] Archiv. f. Hygiene, Bd. 5, 1886.

QUESTIONS INVOLVED.

The problems involved in the proposed investigation are presented diagrammatically.

A brief explanation follows: —

The object of this investigation is to study the influence of hydrogen ion concentration of media upon the proteolytic activity of *B. subtilis*.

After reviewing the previous literature it was necessary to consider the following details of procedure: —

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[1] Green, R. Fermentation. Cambridge Nat. Science Manual, 1899.

[2] Proc. Roy. Soc., 46, 1889, 542.

[3] Archiv. f. Hygiene, V. 10, 1, 1890; V. 14, 1, 1892.

[4] Centralbl. f. Bakt., Abt. I, Bd. 29, U. 35.

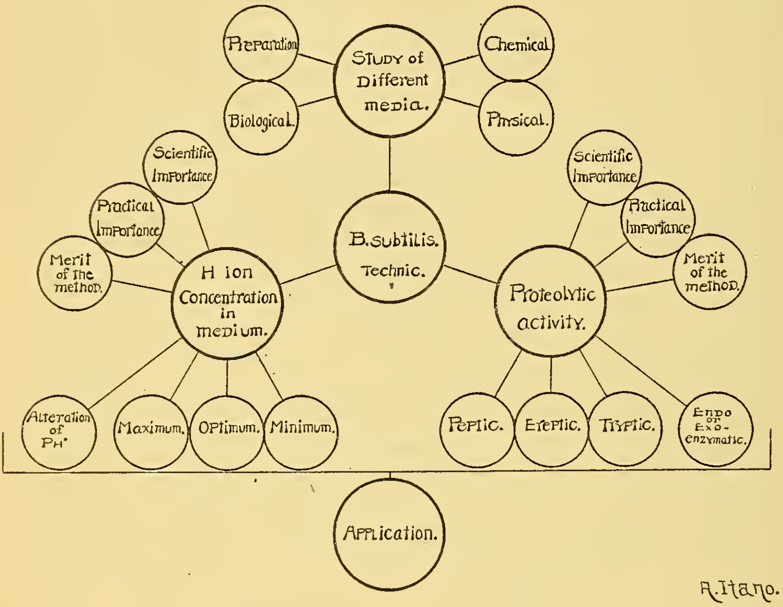
[5] Zeitschr. f. Physiol. Chem., Bd. 51, 294, 1907.

[6] Centralbl. f. Bakt. (Originale), Bd. 73, Heft 6, April, 1914, S. 406–412.

1. Choice of methods to measure —
(*a*) the hydrogen ion concentration in the culture medium.
(*b*) the proteolytic activity quantitatively.

2. Choice of a proper medium, *i.e.*, one which gives uniform results biologically, chemically and physically.

Diagrammatical Representation of the Problems Involved in the Present Investigation.



3. Preparation of media of different hydrogen ion concentrations so that minimum, optimum and maximum hydrogen ion concentration may be determined.

4. Acclimatization to secure organism of constant habit.

5. Inoculation of medium for uniformity of growth.

6. Test for vitality of the organism in media of different hydrogen ion concentration.

7. Determination of the rate of growth.

8. Determination, from time to time, of hydrogen ion concentration.

9. Determination of the rate of proteolysis.

10. Determination of the kind of proteolysis, viz., peptic, ereptic, tryptic-like.

11. Determination of the character of the enzyme, namely, endo- or exo-enzyme.

GENERAL METHODS OF PROCEDURE.

Choice of Methods.

Determination of the Hydrogen Ion Concentration in Culture Media.

A theoretical discussion of "true reaction" will be pertinent at this stage.

"True Reaction" ("True Acidity," "True Alkalinity," "True Neutrality").[1] — The "true acidity" of an acid solution is brought about by the dissociated (hydrogen) ions; therefore the acidity is proportional to the concentration of the dissociated hydrogen ions, and not to the total gram molecules of acid present. For example, if one-tenth normal hydrochloric acid is taken, approximately only 91 per cent. of the total amount of acid becomes dissociated. The "true acidity," *i.e.*, the hydrogen ion concentration, of this solution is only 91 per cent. of the one-tenth normal hydrochloric acid, or ninety-one thousandths normal. The dissociation of weak acid is still less. For instance, in a solution of one-tenth normal acetic acid only $1\frac{3}{10}$ per cent. approximately of the total acid is dissociated, and the hydrogen ion concentration of this solution is therefore thirteen ten-thousandths normal. The "true acidity" of one-tenth normal hydrochloric acid is also about seventy times greater than that of one-tenth normal acetic acid, although both solutions contain the same amount of acid.

The same holds true with the electrically dissociated base in which the metallic and hydroxyl ions are dissociated. The "true alkalinity" of such a solution is not determined by the total amount of base present, but exclusively by the concentration of dissociated hydroxyl ions. For example, in a one-tenth normal solution of the strong base, sodium hydroxide, about 84 per cent. of the total amount of the base is dissociated, and in the case of a weak base, such as ammonium hydroxide, approximately $1\frac{4}{10}$ per cent. of the total amount of the base. The "true alkalinity" of these solutions, therefore, is eighty-four thousandths normal and fourteen thousandths normal, respectively. Thus, regarding the alkalinity as in the case of acidity, we may say in conclusion that "true alkalinity" of a solution is proportional to the concentration of hydroxyl ions.

From the above discussion, "true neutrality" of a solution may be stated as follows: it is a solution in which the same amount of H and OH ions are present. For example, a "true neutral solution," viz., pure water, contains as many hydrogen ions as hydroxyl ions. It can be expressed as follows: —

$$H_2O \rightleftharpoons \overset{+}{H} + \overset{-}{OH}$$

in which $C_{\overset{+}{H}} = C_{\overset{-}{OH}}$, C indicating the concentration.

Again, a solution may not necessarily be neutral, although it contains equivalent quantities of acid and alkali. For example, if a solution which contains hydrochloric acid and sodium hydroxide is taken, it can be expressed in the following manner: —

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[1] Sörensen, S. P. L. Ergebnisse d. Physiologie, 12, 399, 1912.

$$\underset{\text{hydrochloric}}{\underline{\overset{+}{\mathrm{H}}\quad\overset{-}{\mathrm{Cl}}}} + \underset{\text{sodium hydroxide}}{\underline{\overset{+}{\mathrm{Na}}\qquad\overset{-}{\mathrm{OH}}}} = \underset{\text{salt}}{\underline{\overset{+}{\mathrm{Na}}\ \overset{-}{\mathrm{Cl}}}} + \underset{\text{water}}{\underline{\mathrm{HOH}}}$$

This solution is neutral only when it contains just as many hydrogen as hydroxyl ions, or when both the acid and alkali are equally dissociated.

It is understood, therefore, that the "true acidity, alkalinity and neutrality" are not determined by the amount of such substances present, but entirely by the H and OH ion concentration.

With the above facts in mind it becomes possible to enter upon a more intelligent discussion of the methods involved. It has been stated previously that most bacteriologic experiments, having for their purpose the study of reaction upon bacterial life, fall under the following procedures: —

(*a*) Kisch's method.[1]
(*b*) Ordinary titration method.
(*c*) Colorimetric method.

It is well known that Kisch's method is a dilution method wherein a certain number of gram molecules of an acid or alkali are diluted to a definite quantity for the purpose of ascertaining the influence of the reaction upon the life of bacteria. There are two distinct ways to apply Kisch's method, namely: (*a*) immersing the bacteria in different dilutions of acids or alkalis in pure water for different periods of time by means of silk threads or any other convenient agents, and then testing their vitality; or (*b*) adding a known percentage of acids or alkalis directly to the culture medium (usually solution). In either case the results obtained by Kisch's method indicate neither the influence of "true reaction" upon bacterial life nor the influence of molecular concentration, because, as Lingelheim[2] has shown, different acids of the same molecular concentration have varying influence upon bacteria, and the degree of influence is parallel to the dissociation constant of an acid or alkali. This is especially true in the case of the second manner of application, (*b*), where adsorption is caused by the culture medium.

The ordinary titration method is generally employed in adjusting reaction of culture medium, and also to measure the amount of acid or alkali produced in the course of physiologic tests. This method is inaccurate in the study of physiologic liquids containing more or less amphoteric substances and a comparatively small quantity of H or OH ions. In other words, it is impossible to determine the " true reaction " in such a liquid by this method. Fuller's[3] and Schültz's[4] methods of adjusting the scale of reaction of culture media are scientifically condemned by the recent investigation of Clark,[1] who showed the fallacies of the titrimetric method. Again, the adsorption phenomenon caused by the amphoteric substance in the course of titration is well known, and, in the case of albumin, is usually expressed in the following manner: —

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[1] Biochem. Zeitschr., 40, 152, 1912.

[2] Zeitschr. f. Hyg., 8, 201.

[3] Jour. Amer. Pub. Health Assn., 1895, 20, 381.

[4] Centralbl. f. Bakteriol., O, 1891, 10, 52.

$$\text{In acid solution} \quad \text{H. albumin. OH} = \overset{+}{\text{H albumin}} + \overset{-}{\text{OH}}$$

$$\text{In alkali solution} \quad \text{H. albumin. OH} = \overset{-}{\text{Albumin OH}} + \overset{+}{\text{H}}$$

The correctness of the above statement has been experimentally demonstrated by Sörensen,[2] Clark[3] and others.

In many cases the colorimetric method gives fairly accurate results,[4] but it has been noted that the presence of neutral salts as well as amphoteric substances interfere with the determination.[5] It may, however, be employed successfully if it is standardized for the particular liquid.[6] Lately Clark and Lub[7] employed the principle of the colorimetric method for the differentiation of the colon-ærogenes family, using suitable indicators. They have based their experiment upon the wide divergence of the hydrogen ion concentration in a culture of one group and of the other, and distinguished this difference by means of paranitrophenol or methyl red. The use of this method for physiologic work other than bacteriology has been practiced by many. Sörensen and Palitzsch[8] determined the hydrogen ion concentration of sea water. Henderson and Palmer[9] used it in determining the acidity of urine to diagnose normal and abnormal conditions. In any case, the colorimetric method should be standardized previous to its use, by means of the hydrogen electrode.

Examining these methods critically in the light of physical chemistry they are not satisfactory for the purpose of ascertaining the influence of the so-called "true reaction" upon bacterial life. The hydrogen electrode was devised to determine the hydrogen ion concentration, and it has been used successfully in biologic fields. This method has been employed in the present investigation, and its theoretical and practical discussion follows.

Theory of H Ion Concentration. — The announcement of the theory of electric dissociation by Svante Arrhenius, in 1887, marked a new era in physical chemistry. It was F. Kohlrausch and A. Heydweiller who demonstrated that even the purest water is a conductor of electricity, and accordingly prepared a distilled water of the least specific conductance. They measured the specific conductance by means of electric conductivity.

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[1] Jour. of Infect. Diseases, V. 17, No. 1, July, 1915, 109.

[2] Ergebnisse d. Physiologie, Bd. 12, 423, 1912.

[3] Jour. of Infect. Diseases, V. 17, No. 1, July, 1915, 109–136.

[4] Michaelis, L. Die Wasserstoffionenkonzentration, 176, 1914.

[5] Michaelis, L., and P. Rona. Biochem. Zeitschr., 23, 61, 1909.

[6] Michaelis, L. Die Wasserstoffionenkonzentration, 176, 1914.

[7] Jour. of Infect. Diseases, V. 17, No. 1, July, 1915, 160–173.

[8] Biochem. Zeitschr., 51, 307, 1913.

[9] Jour. of Biol. Chem., V. 13, No. 4, Jan., 1913.

Later, other methods for the estimation of dissociation were established, and the results obtained by Kohlrausch were confirmed. Now it is proved that a very small portion of the water molecule is dissociated into two electrically charged parts (or ions), as follows: —

$$H_2O \rightleftharpoons \overset{+}{H} + \overset{-}{OH}$$

Its dissociation takes place according to the law of mass action in accordance with the following equation: —

$$\frac{(H)(OH)}{(H_2O)} = K \qquad (1)$$

in which K denotes the ionization constant; that is to say, the product of the hydrogen and hydroxyl ion concentration, divided by the concentration of the undissociated water molecule, should be constant.

The concentration of water is generally constant. Therefore it may be expressed as follows: —

$$(H) . (OH) = Kw \qquad (2)$$

in which Kw denoted $K.H_2O$, or ionization constant of water.

Equation (2) is another form of equation (1).

NOTE. — (H) and (OH) express the concentration.

This ionization constant of water has been determined by several noted physical chemists, and found to be 10^{-14} at 22° C.; that is,

$$(H) . (OH) = Kw \quad \text{or}$$

$$Kw = 10^{-14} \qquad (3)$$

Since pure water is a neutral solution it contains the same number of dissociated hydrogen and hydroxyl ions. Therefore equation (3) can be expressed as follows: —

$$10^{-7} \times 10^{-7} = 10^{-14} \qquad (4)$$

That is, a pure water contains of each 10^{-7} dissociated hydrogen and hydroxyl ions, or .0000001 gram ions per litre, which is, in a general term, one ten-millionth normal $\frac{N}{10,000,000}$. The acidity, alkalinity and neutrality, therefore, are expressed in terms of hydrogen ion concentration in the following manner: —

Acid reaction $(H) > 10^{-7}$
Alkaline reaction $(H) < 10^{-7}$
Neutral reaction $(H) = 10^{-7}$

NOTE. — $(\times)$ = notation of the concentration of ions.

That is, in an acid solution there are more than $\frac{1}{10,000,000}$ gram molecule of dissociated hydrogen; in an alkaline solution, less; and in a neutral solution, just $\frac{1}{10{,}000{,}000}$ gram molecule. Thus the reaction is usually expressed in terms of hydrogen ion concentration unless it is indicated otherwise.

From the above discussions it is readily seen that if the ionization constant is known, and the hydrogen ion concentration is determined experimentally, then the hydroxyl ion concentration can be calculated. The determination of hydrogen ion concentration is accomplished by the use of the gas cell, of which the principle is based upon the potential of the chain. This chain, as described in physical chemistry, consists of —

Hg – HgCl	n/10 KCl	conc. KCl	solution	Pt H_2
calomel	electrode	concentr. potassium chloride in a dish.	(unknown)	platinum electrode saturated with hydrogen gas.

The potential of such a chain can be determined by the usual physical method. Then the relation between the measurement of potential and hydrogen ion concentration can be calculated by the following equation: —

$$P_{\dot{H}} = \frac{P - 0.3377}{0.0577 + 0.0002\ (t^\circ - 18^\circ)}$$ [1]

where —

$P_{\dot{H}}$ — the term adopted by S. P. L. Sörensen to express the exponent of gm. — equivalent of hydrogen ions per liter.[2]

P — the total E. M. F. of the chain. It can be determined by the following equation, having the apparatus arranged as it is shown in the diagram: —

$P = \frac{R_1 \times 1.0189}{R}$, in which R_1 — the bridge reading for the chain against an accumulator.

R — the bridge reading for the accumulator against the normal element.

1.0189 — the voltage of the normal element at 18°C. (standard).

0.3377[3] — the sum of potential of calomel electrode (N/10 KCl) and hydrogen electrode in a solution where the hydrogen concentration is normal $(H) = 1$ or $P_{\dot{H}} = 0$.

0.0577[4] — thermodynamical factor at 18° C. which is influenced by temperature, 0.0002 for each degree centigrade, or it changes as follows: —

$0.0577 + 0.0002\ (t^\circ - 18^\circ)$, of which t° equals temperature at the time of determination.

After $P_{\dot{H}}$ is determined it is necessary to understand the value of H ion concentration, although the experimental results are generally expressed in $P_{\dot{H}}$. It will be shown at the end of an example, illustrating the application of the formula as well.

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[1] Sörensen, S. P. L. Ergebnisse d. Physiologie, 12, 416, 417, 1912.

[2] This will be explained further by an illustration on the following page.

[3] Bjerrum. *Ibid.*, 53, 428, 1905.

[4] W. Nernst. Zeitschr. physik. Chem., 4, 129, 1889.

Example.

t° = 19.2° C (constant during the experiment).

$R_1 = 307.0$ (constant reading on the bridge at five minute interval).

R = 500.2 (as above).

E. M. F. of the normal element = 1.0189.

Then the total E. M. F. of the chain can be calculated as follows: —

N.E. = normal element.
Ac. = accumulator.
x = the chain.
1000 = scale on bridge.

$$\frac{307.0}{1000} = \frac{x}{\text{Ac.}}; \quad \frac{500.2}{1000} = \frac{\text{N.E.}}{\text{Ac.}}$$

$$x = \frac{307.0 \text{ Ac.}}{1000} \qquad (1)$$

$$\frac{500.2}{1000} = \frac{\text{N.E.}}{\text{Ac.}}$$

$$\text{Ac.} = \frac{1000 \text{ N.E.}}{500.2}$$

$$= \frac{1000 \times 1.0189}{500.2} \qquad (2)$$

Substituting (2) in (1),

$$x = \frac{307.0}{1000} \times \frac{1000 \times 1.0189}{500.2}$$

$$= 0.6254 \text{ volt, which is expressed p.}$$

Substituting the value for p in the formula,

$$P_{\dot{H}} = \frac{0.525 - 0.3377}{0.0577 + 0.0002\ (19.2 - 18)}$$

$$= 4.967$$

or in terms of H ion concentration,

$$P_{\dot{H}} = 4.967 = -4.967 \text{ (log. H)}$$

$$10^{-4.967} = 1.0789 \times 10^{-5}$$

$$H = .000010789$$

Besides the apparatus[1] listed above, a H-generator was employed, which is a good-sized Kipp's generator used with a series of washing bottles and drying tube, consisting of (*a*) 30 per cent. KOH, (*b*) alkaline pyrogallic acid, (*c*) conc H_2SO_4 and soda lime in U-tube. Since a considerable amount of CO_2 is produced during the course of metabolism, the same precaution is taken as with blood. For this purpose Hasselbach's electrode with shaking arrangement is employed.

In setting up the apparatus special attention should be paid to rigidness, insulation and temperature. In order to meet with these requisites the apparatus was placed on a big central table in the laboratory. First, one dozen large glass rings of the same height were distributed over the top of the table. These supported a thick glass plate on which several blocks of paraffine for each piece of apparatus were placed. Thus it was possible to obtain a perfect insulation.

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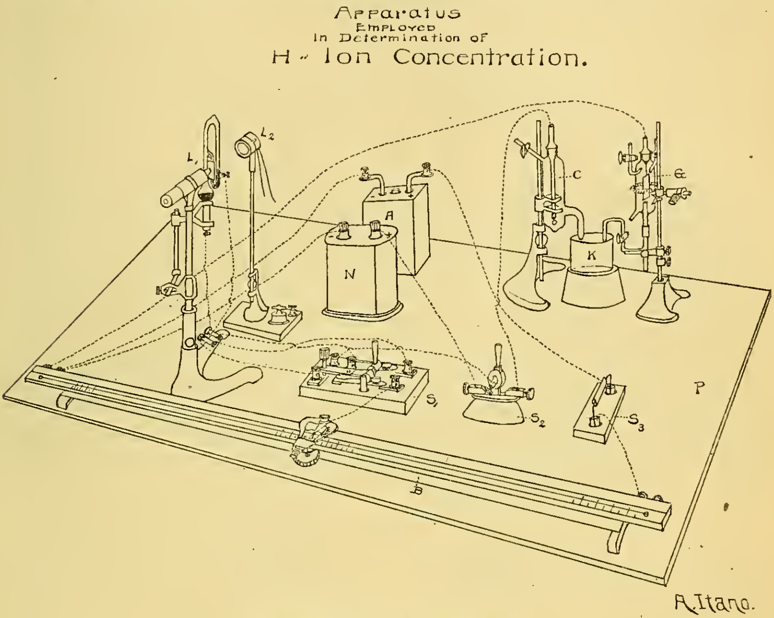
[1] This set of apparatus can be obtained from Fritz-Köhler factory in Leipzig, Germany.

In preparing the different parts of the apparatus extreme care should be exercised to obtain an accurate result. The method for the preparation of the normal element, calomel electrode, gas cell, and also calibration of the bridge wire,[1] etc., is described in detail in Findlay's "Practical Physical Chemistry." Every contact should be carefully made, so that accurate readings can be obtained. It is worthy of mention that the diffusion potential between n/10 KCl calomel electrode and the solution to be tested is reduced by interposing the saturated solution of KCl as it is indicated by K on the diagram. For the standardization of the electrode it was first platinized with general precaution; then the hydrogen ion concentration of the mixed solution (7 c. c. of m/15 KH_2PO_4, 3 c. c. of m/15 Na_2 HPO_4)[2] was determined at different intervals. After the readings became constant there was a difference of 0.0005 volts between the theoretical data and the results obtained.



Description of Diagram.

L_1 — Lippmann's capillarimeter.
L_2 — Tungston lamp.
A — Accumulator.
N — Western normal element.
S_1 — Switch with quick short circuiting key.
S_2 — Three-way switch.
S_3 — Two-way switch.
C — Calomel electrode.
K — Concentrated KCl cup.
G — Gas cell.
B — Bridge.
P — Thick glass plate.

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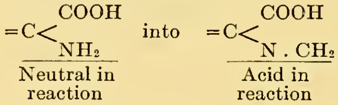
[1] The author is greatly indebted to Professor Thompson, department of physics, Amherst College, for his kind advice.

[2] Sörensen's standard solutions.

Methods for Quantitative Determination of Proteolysis.

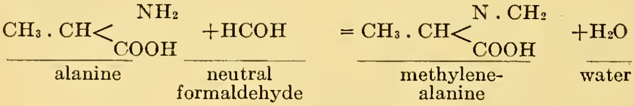
Previous to the recent development of protein chemistry and methods for the determination of cleavage products of proteins, the quantitative determination of proteolysis was not successful. With Hlaswetz and Habermann's[1] successful researches, and the investigations of Kossel and Kutscher,[2] together with the remarkable findings of E. Fischer,[3] Abderhalden,[4] Plimmer[5] and other recent workers, the chemical nature of proteins began to assume more definite form. Then several methods for determining cleavage products were advanced. Since the proteolysis is mainly the hydrolytic splitting of proteins, the degree of proteolysis can be followed quantitatively by determining the amount of the cleavage products from time to time. It is most important for our purpose to find a method which enables us to determine the amino acids as a group, because we naturally expect the amino acids as extended cleavage products. Sörensen's formol titration method[6] has been selected for this purpose. This has been done only after reviewing Hausmann and Osborn's,[7] as well as Van Slyke's methods.[8] Sörensen's method has decided advantages in ease of manipulation and accuracy when properly employed.

Theoretical Discussion of Formol Titration. — The reaction taking place between formaldehyde and amino acids, as well as its application to the quantitative determination of amino acids, was first shown by Hugo Schiff.[9] The formaldehyde converts the radical



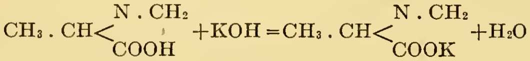
$$\underset{\text{Neutral in reaction}}{\underline{=\mathrm{C}\!\left\langle\begin{matrix}\mathrm{COOH}\\ \mathrm{NH_2}\end{matrix}\right.}} \quad \text{into} \quad \underset{\text{Acid in reaction}}{\underline{=\mathrm{C}\!\left\langle\begin{matrix}\mathrm{COOH}\\ \mathrm{N\,.\,CH_2}\end{matrix}\right.}}$$

For example: —



$$\underset{\text{alanine}}{\underline{\mathrm{CH_3\,.\,CH}\!\left\langle\begin{matrix}\mathrm{NH_2}\\ \mathrm{COOH}\end{matrix}\right.}} + \underset{\text{neutral formaldehyde}}{\underline{\mathrm{HCOH}}} = \underset{\text{methylene-alanine}}{\underline{\mathrm{CH_3\,.\,CH}\!\left\langle\begin{matrix}\mathrm{N\,.\,CH_2}\\ \mathrm{COOH}\end{matrix}\right.}} + \underset{\text{water}}{\underline{\mathrm{H_2O}}}$$

That is, the addition of neutral formaldehyde to the practically neutral solution of alanine, which can be titrated with the standardized alkaline solution in accordance with the following equation: —



$$\mathrm{CH_3\,.\,CH}\!\left\langle\begin{matrix}\mathrm{N\,.\,CH_2}\\ \mathrm{COOH}\end{matrix}\right. + \mathrm{KOH} = \mathrm{CH_3\,.\,CH}\!\left\langle\begin{matrix}\mathrm{N\,.\,CH_2}\\ \mathrm{COOK}\end{matrix}\right. + \mathrm{H_2O}$$

That is, a simple neutralizing reaction.

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[1] Ann. (Leipzig), 169, 150, 1873.

[2] Zeit. Physiol. Chem., 22, 176, 1896–97; 25, 165, 1895.

[3] Untersuchungen über Aminosäuren, Polypeptide und Proteins, Berlin, 1906.

[4] Abderhalden, E. Lehrbuch d. Physiologischen Chemie, Teil 1, 307–652, 1914.

[5] Plimmer, R. H. The Chemical Constituent of the Proteins, Monograph on Biochemistry.

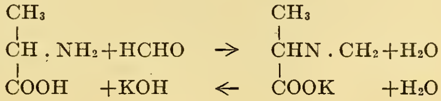
[6] Sörensen, S. P. L. Comptes Rendus 7me. Ire Livraison, 1907.

[7] Zeit. Physiol. Chem., 27, 95, 1899; 29, 136, 1900.

[8] Proc. Soc. Exp. Biol. and Med., 7, 46, 1910; Berichte d. D. Chem. Ges., 43, 3170, 1910.

[9] Schiff, H. Ann. der Chemie, 310, 25, 1899; 319, 59 et 289, 1901; 325, 348, 1902.

Schiff studied further to apply this reaction to the quantitative determination of amino acids, polypeptides and other similar compounds. His attempt was not wholly successful because he neglected to consider all factors involved in the process. For instance, the amount of potassium hydroxide, water and other substances which are used in the titration should be considered in order to obtain accurate results. This was shown by Sörensen, who pointed out the reversibility of such a reaction as is indicated below: —



$$\begin{array}{lcl} \text{CH}_3 & & \text{CH}_3 \\ | & & | \\ \text{CH . NH}_2+\text{HCHO} & \rightarrow & \text{CHN . CH}_2+\text{H}_2\text{O} \\ | & & | \\ \text{COOH} \quad +\text{KOH} & \leftarrow & \text{COOK} \quad +\text{H}_2\text{O} \end{array}$$

He also found that the equilibrium of the system depends upon the quantity of each of the chemicals present. For example, from the above reaction it can be clearly seen that an increase of potassium hydroxide, or, in other words, of hydroxyl ions, in the system would result in an action similar to an increase of the formaldehyde. In order to control these sources of error, Sörensen chose an indicator which turns with such a high concentration of hydroxyl ions that the process could be finished from left to right. He used phenolphthalein and titrated to a strong red color with n/5 KOH. Thus he studied the method very carefully, and succeeded in conducting it with such precision that he had only 0–5 per cent. error when he observed certain conditions which will be enumerated in an example to be cited soon.

Further, Sörensen extended the formol titration method to proteolysis, and found that it can be depended upon for accurate quantitative determinations. He based his principle upon the fact that proteolysis is mainly the hydrolytic splitting of protein, and takes place by the addition of a water molecule. It is a differential method as illustrated below: —

$X-Y=Z$, where X is amount of amino acids present after proteolysis takes place; Y, the same, before; Z the same produced by the proteolysis.

In order to carry out the determination, all other acids in the liquid should be eliminated; that is, the liquid must contain as many H ions as OH ions at the beginning. If all these precautions are observed the amount of alkali used in the titration after the addition of neutral formaldehyde should be equal to the amount of the amino acid group present. After finding X and Y, Z, or the index of degree of proteolysis, can be determined.

EXAMPLE.

Preparation of Solutions and Reagents.

(*a*) 125 c. c. 4 per cent. Witte's peptone solution
75 c. c. 0.2 per cent. pancreatin solution } total volume, 250 c. c.
50 c. c. distilled water

(*b*) Standard acid solution: n/5 HCl is prepared by standardizing against sodium oxalate which is obtained from the Bureau of Standards.

(*c*) Standard alkali solution: n/5 KOH is prepared by titrating against the above standard acid.

(*d*) Indicators: (1) Phenolphthalein — dissolve 0.5 gram of phenolphthalein in 500 c. c. alcohol and make it to a liter. (2) Litmus paper — a narrow strip of Kahlbaum litmus paper.

(*e*) Reagents: (1) Neutral formaldehyde — 50 c. c. of 40 per cent. commercial formaldehyde with 1 c. c. of the phenolphthalein is neutralized to rose color. (2) Bismark-brown, tropæolin 0 and 00 and methyl violet — these reagents are prepared by dissolving 0.2 gram of the substance in one liter of water.

(*f*) Water; carbon dioxide and ammonia-free distilled water. This is prepared with usual precautions.

(*g*) Test solution. This is prepared with equal portions of m/15 KH_2PO_4 and m/15 Na_2HPO_4, and is perfectly neutral.

Determination.

I. Right after the preparation of solution (*a*): —

Transfer 20 c. c. of the water (*g*) into a 50 c. c. flask and the same amount of the solution (*a*) into another. Adjust the color of the water to the latter by adding about 2 drops of bismark-brown in this case, and use any one of the mixtures of tropæolin 0 and 00 or methyl violet to obtain a comparative coloration; neutralize it to litmus, controlling the neutralization point by means of the test solution. Add 10 c. c. of the neutral formaldehyde. Titrate it to a dark red color with the standard alkali, and titrate it back to strong red color with the standard acids. Record the number of c. c. of standard acid and alkali used. Treat the flask with the solution (*a*) in the same manner, except adjusting the coloration. After titrating it to dark red color titrate it back to its former color with (*a*).

Results.

	Control (water).	Sample (peptone solution).
Number of c. c. used n/5NaOH	1.20 c. c.	3.35 c. c.
Number of c. c. used n/5 HCl	1.10	.33
	0.10 n/5 NaOH	3.02
		.10 (control)
		2.92 n/5 naOH

Since

1 c. c. n/5 NaOH = 2.8 milligrams of amino nitrogen,

2.92 × 2.8 = 8.176 milligrams amino nitrogen in 20 c. c. of the solution. This is designated as Y in the above equation.

II. After fifteen hours incubation at 40° C.: —

The rest of the solution (*a*) was placed in incubator at 40° C. right after 20 c. c. had been taken out for the above determination, and was kept there for sixteen hours. At the end of that period 20 c. c. of the solution was drawn out for titration, and treated in the same manner.

Results.

	Control.	Sample.
Number of c. c. NaOH	1.8	8.15
Number of c. c. HCl	0.1	.10
	1.7 n/5 NaOH	8.05
		1.70 (control)
		6.35 c. c. n/5 NaOH

6.35 × 2.8 = 17.780 milligrams of amino nitrogen. This is indicated as X.

$X - Y = Z.$

17.780 − 8.176 = 9.604 milligrams of amino nitrogen was produced by proteolysis during the sixteen hours' incubation.

Thus, the proteolysis can be followed from time to time.

In applying this method in the present investigation it may be clearly seen from the preceding discussions that the proteolysis can be followed accurately by determining the difference between the amount of amino acid present in the original culture medium and after the growth of an organism in it. It is, however, necessary to exercise special care in regard to the presence of ammonia and carbon dioxide, produced in the course of deamidation, which interferes with the determination. To avoid these sources of error ammonia and carbon dioxide-free air was passed through the media, which were made alkaline by the addition of n/1 NaOH previous to determination.

PREPARATION OF MEDIA.

Steps in Selection of Medium.

Common experiences dictate that the properties of media are influenced by constituents and technic of preparation. To obtain stable and comparable data is essential in these investigations from the standpoint of biology, chemistry and physics because a very slight variation will furnish unsatisfactory results. Several media were carefully tested.

Medium I.: —

1,000 grams chopped lean beef.
1,000 c. c. distilled water.

Medium II.: —

1 per cent. Liebig's meat extract.
1,000 c. c. distilled water.

Medium III.: —

1 per cent. Witte's peptone.
0.5 per cent. NaCl.
1,000 c. c. distilled water.

Medium IV.: —

1 per cent. Liebig's meat extract.
1 per cent. Witte's peptone.
0.5 per cent. NaCl.
1,000 c. c. distilled water.

The method of preparation and testing is outlined below.

Medium I. — Five hundred grams of chopped lean beef were obtained from a local meat market and immediately well mixed. Ten lots of 30 grams each were weighed out and each lot was transferred into a 250 cubic centimeter Erlenmeyer flask. These flasks were marked *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k* and *l*, and divided into groups, one *a* to *f*, inclusive, marked A, and the other, *g* to *l*, inclusive, marked B. Group A was treated directly, while group B was placed in an incubator at 37° C. for twenty-four hours. After an addition of 300 cubic centimeters of distilled water to the former the flasks were shaken for thirty minutes. At the end of this period the extract was prepared from flask *a* by straining through two layers of cheesecloth and filtering through Swedish filter paper. This extract will be designated as "original" in Table I. The remaining flasks were placed in a water bath at 40° C. and kept for forty minutes with frequent stirring. Flask *b* was then removed, and the extract was prepared in the same manner as the "original." Flasks *c*, *d*, *e* and *f* were brought to the boiling point. Flask *c* was removed at the end of ten minutes, *d* at the end of thirty minutes, *e* at the end of forty-five minutes and *f* at the end of sixty minutes. Each extract was prepared after careful counterweighing. The foregoing extracts were used for further study. After twenty-four hours incubation at 37° C. group B was treated identically as group A.

Medium II. — In this medium Liebig's meat extract was used instead of fresh lean beef, and three separate lots were prepared, namely, A, B and C. Lot A was prepared by taking 2 grams of Liebig's meat extract secured from one jar; B, the same amount of the meat extract from a second jar; and C, the same amount, from a third jar. The object of preparing lots A, B and C in Medium II. was to measure any difference which might exist among the containers of Liebig's meat extract. The preparation of these lots from this point is identical. To each, 200 cubic centimeters of distilled water were added and the whole shaken for thirty minutes. At the end of this time, 30 cubic centimeters of the mixture were removed from each flask. The rest was then immersed in the water bath at 40° C. for forty-five minutes. Again 30 cubic centimeters of the mixture were taken out from each. The remainder was then brought to the boiling point and held for ten, forty-five and sixty minutes, 30 cubic centimeters of the mixture being removed at the end of each period. After each operation the flask was carefully counterweighed.

Medium III. — In this medium two separate lots, namely, A and B, were prepared. Ten grams of Witte's peptone obtained from each of two different bottles were used, respectively, for lots A and B. By this means it was hoped to note any difference existing in Witte's peptone taken from different containers. The preparation of A and B from this point on is identical. After 5 grams of NaCl had been added to each, a paste was made with 50 cubic centimeters distilled water. The whole was then made up to one liter. This was shaken for thirty minutes and treated in the same manner as Medium II., with these exceptions: 100 cubic centimeters were heated in an autoclave for thirty minutes under 15 pounds' pressure; 300 cubic centimeters were subjected to fractional sterilization for fifteen minutes on three successive days.

Medium IV. — In this medium three separate lots, namely, A, B and C, were made up at three different times from the same materials. These different lots were prepared and treated alike, as follows: 10 grams Liebig's meat extract were dissolved in 500 cubic centimeters distilled water. This was thoroughly shaken for thirty minutes. At the same time, 10 grams of Witte's peptone and 5 grams NaCl were mixed separately into a smooth paste with 200 cubic centimeters distilled water, and the volume was made up to 500 cubic centimeters. This was shaken for thirty minutes. These two portions were then mixed thoroughly and treated in the same manner as Medium III., with the following additional physical determinations, namely, osmotic pressure, viscosity, surface tension and specific conductance. Such determinations were made by taking samples after subjecting the mixture to the autoclave. In addition to these, the total nitrogen was determined by the Kjeldahl method. The results will be given in Table I.

TABLE I. — *Experiment with Different Media.*

Media.		Properties.	Treatment.										Physical Properties.				Growth.
					Boiling.				Auto-clave.	Fractional Sterilization.							
No.	Lot.		Original.	40 Minutes at 40° C.	10 Minutes.	30 Minutes.	45 Minutes.	60 Minutes.	30 Minutes.	First Day.	Second Day.	Third Day.	a Osmotic Pressure.	b Viscosity.	c Surface Tension.	Specific Conductance.	
I.	A.	P_H	5.45	5.47	5.50	5.71	5.72	5.72	-	-	-	-	-	-	-	-	-
		F.N.	58.80	65.40	75.30	74.20	75.30	77.00	-	-	-	-					
	B.	P_H	5.37	5.47	5.44	5.68	5.56	5.52	-	-	-	-					
		F.N.	137.50	142.70	146.00	151.10	163.00	178.10	-	-	-	-					
II.	A.	P_H	5.54	5.74	5.77	5.79	5.71	5.71	-	-	-	-	-	-	-	-	-
		F.N.	19.60	26.60	28.00	29.40	30.80	32.20	-	-	-	-					
	B.	P_H	5.59	5.71	5.64	5.77	5.72	5.79	-	-	-	-					
		F.N.	19.40	25.20	26.60	30.80	30.81	32.20	-	-	-	-					
	C.	P_H	5.58	5.72	5.79	5.72	5.79	5.71	-	-	-	-					
		F.N.	22.40	26.60	26.40	32.20	32.30	32.30	-	-	-	-					

III.	A.	P_H	6.88	6.66	6.90	6.82	6.92	6.92	6.91	6.92	6.90	6.91	–	–	–	–	–
		O.T.	0.60	0.65	0.62	0.60	0.58	0.60	0.70	0.65	0.62	0.65					
		F.N.	11.20	27.30	36.40	36.40	39.40	39.40	38.80	37.80	40.00	39.40					
	B.	P_H	6.79	6.90	6.65	6.86	6.91	6.90	6.87	6.89	6.90	6.87					
		O.T.	0.58	0.61	0.60	0.62	0.65	0.60	0.64	0.60	0.59	0.62					
		F.N.	11.60	29.20	35.00	37.50	39.00	39.50	39.20	38.00	39.00	38.00					
IV.	A.	P_H	6.12	6.35	6.13	6.12	6.22	6.16	6.17	6.15	6.12	6.21	6.694	1.155	0.9089	14.40×10^{-3}	Abundant.
		O.T.	2.10	2.25	2.15	2.30	2.10	2.25	2.15	2.30	2.20	2.20					
		T.N.	232.0	–	–	–	–	–	–	–	–	–					
		F.N.	29.40	31.60	32.20	32.20	44.80	46.20	46.20	47.60	48.20	47.60					
	B.	P_H	6.15	6.12	6.31	6.16	6.15	6.12	6.15	6.16	6.12	6.16	6.653	0.150	0.9080	14.35×10^{-3}	Abundant.
		O.T.	2.20	2.15	2.30	2.25	2.20	2.15	2.20	2.10	2.35	2.25					
		T.N.	225.0	–	–	–	–	–	–	–	–	–					
		F.N.	29.50	29.40	30.16	32.60	43.60	47.60	46.20	46.20	47.60	46.50					
	C.	P_H	6.16	6.25	6.12	6.15	6.16	6.26	6.15	6.16	6.21	6.22	6.673	1.148	0.9090	14.20×10^{-3}	Abundant.
		O.T.	2.10	2.15	2.35	2.25	2.30	2.35	2.15	2.30	2.20	2.20					
		T.N.	228.5	–	–	–	–	–	–	–	–	–					
		F.N.	31.60	32.20	32.50	33.60	46.20	47.60	44.80	49.00	50.20	50.10					

P_H — Exponent of Hydrogen Ion Concentration.
O.T. — Ordinary titration (Fuller's scale).
T.N. — Total nitrogen (mg. per 100 c. c.).
F.N. — Formol titrating nitrogen (mg. per 100 c. c.).
(*a*) — **In** term of atmospheric pressure; (*b*) and (*c*) — water as 1.

Summary of Table I.

Medium I.

Lots A and B. — Table I. indicates an increase in both P_H and the amount of the formol titrating nitrogen as the treatment continued. The decrease in the hydrogen ion concentration may be due to the volatility of an organic acid, and the increase of the formol titrating nitrogen is apparently caused by hydrolysis in the course of treatment. These changes became constant after the media were boiled for forty-five minutes or longer. On the other hand, there is a marked difference between lots A and B from the standpoint of the hydrogen ion concentration and the amount of the formol titrating nitrogen; especially, the amount of the formol titrating nitrogen in lot A is much greater than in lot B. This is very interesting, because it indicates the possible existence of such variation in the same lot of chopped lean beef.

Medium II.

Lots A, B and C. — The same changes occurred in each lot as in Medium I., namely, a decrease of hydrogen ion concentration and an increase of the formol titrating nitrogen. The variations among the lots A, B and C were slight, however. This indicates that Liebig's meat extract from different jars gives fairly uniform results.

Medium III.

Lots A and B. — The same changes were observed in this medium as in Medium II. It is also seen that the properties of the medium became almost constant after it was autoclaved. Both lots A and B agree with each other very closely. Significantly the rate of increase of the formol titrating nitrogen is very marked in this medium.

Medium IV.

Lots A, B and C. — The same phenomena were observed in this medium as in the others. After their properties became uniform there was very slight variation among them.

Biologic Test of Medium IV. — After it was found that Medium IV. gave uniform results chemically and physically, an approximate biologic test was applied macroscopically in the following manner. Two test tubes for each lot were prepared and filled with 10 cubic centimeters of the medium, respectively. They were then sterilized. One test tube from each lot was kept for control, and the other was inoculated with *B. subtilis.* They were placed in the incubator at 37° C., and an observation was made each day for six successive days.

Table II. — *Growth of B. Subtilis in Medium IV.*

	24 Hours.	48 Hours.	72 Hours.	96 Hours.	120 Hours.	144 Hours.
Lot A: —						
Control,	—	—	—	—	—	—
Culture,	+	++	+++	+++	+++	+++
Lot B: —						
Control,	—	—	—	—	—	—
Culture,	+	++	+++	+++	+++	+++
Lot C: —						
Control,	—	—	—	—	—	—
Culture,	+	++	+++	+++	+++	+++

— indicates no growth.
+ indicates slight growth.
++ indicates strong growth.
+++ indicates abundant growth.

So far as the macroscopical examination was concerned abundant and uniform growth took place in each lot.

Medium IV., having satisfied the chemical, physical and biological tests better than Medium I., II. and III., and being in regular use in microbiologic work, it appeared as suitable as any for the investigation under way.

Preparation of Media of Different Hydrogen Ion Concentration.

In the previous experiment Medium IV. was found to be satisfactory so far as it had been investigated. It is now necessary to adjust its reaction by the addition of acid or alkali, so that a series of the medium of various hydrogen ion concentrations, viz., $P_{\dot{H}}=1$ to 13, may be obtained. Only thus can it be employed to accomplish the purpose of the proposed investigation.

It is not an easy task, however, to secure such a series of hydrogen ion concentrations in such a medium, because the presence of amphoteric substances and mechanical factors involved in the course of preparation should be taken into consideration. First, to obtain the approximate amount of acid or alkali to be added the colorimetric method was resorted to.

The Colorimetric Method.[1] — On the one hand is the medium, on the other the standard solution of known hydrogen ion concentration. An organic dye that changes color with a variation in the amount of hydrogen ion concentration is employed as an indicator. The indicator is added to the standard solution, as well as the sample medium for comparison of colors. An estimate of the hydrogen ion concentration is made possible by this means.

Concretely: To ascertain the hydrogen ion concentration, 5 drops of methyl red[2] were added to 10 cubic centimeters of Medium IV. A yellowish green color was observed. Since methyl red gives this color in a solution in which hydrogen ion concentration is greater than $P_{\dot{H}}=6$, this medium must contain more than $P_{\dot{H}}=6$. To make the determination more exact, several standard solutions were prepared, and the colors produced with the indicator were traced to identical shades alike in standard solution and medium. Mixing m/15 KH_2PO_4 and m/15 Na_2HPO in various proportions, as in the table below, the different hydrogen ion concentrations ranging from $P_{\dot{H}}=6.24$ to $P_{\dot{H}}=7.35$ were obtained.

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[1] Sörensen, S. P. L. Compt. rend. du Lab. de Carlsberg, 8, 1, 1909, 67.

[2] Prepared according to S. P. L. Sörensen.

TABLE III. — *Standard Solution of Different* $P_{\dot{H}} = (6.24\text{–}7.35)$.

NUMBER OF TEST TUBE.	Number of Cubic Centimeters of m/15 KH_2PO_4.	Number of Cubic Centimeters of m/15 Na_2HPO_4.	$P_{\dot{H}} = x$.
1,	5	5	6.81
2,	6	4	6.98
3,	7	3	7.15
4,	8	2	7.35
5,	4	6	6.65
6,	3	7	6.47
7,	2	8	6.24

m = molecular.

Before an indicator[1] is added to the standard solution, it is important to adjust the color of the standard solution itself to the identical color of the medium. If this adjustment is neglected it is impossible to compare the color produced in each, upon the addition of the indicator. For this purpose 4 drops of tropæolin 0, as previously suggested, and the same amount of methyl violet, gave an almost identical color upon very careful comparison. Finally, 10 drops of neutral red[2] were added to both the standard solution and the medium. Then the color was compared by the usual method, and it was found that the color of the medium corresponded to the color which was intermediate between tubes No. 6 and No. 7, or approximately $P_{\dot{H}} = 6.35$. Therefore Medium IV., without any addition of either acid or alkali, contained $P_{\dot{H}} = 6.35$ according to the findings of this method.

An attempt was next made to prepare a series of $P_{\dot{H}} = 2$, 4, 8 and 10, after finding the $P_{\dot{H}}$ in the medium by adding various amounts of n/5 HCl and n/5 NaOH, so that other $P_{\dot{H}}$ can be obtained by interpolation. For this purpose 10 cubic centimeters of the medium was taken and treated as in the preceding processes, except that a suitable standard solution and indicators for the different $P_{\dot{H}}$ were used.

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[1] In this case neutral red which gives a rosy red to orange colors within the range from $P_{\dot{H}} = 6$ to $P_{\dot{H}} = 10$.

[2] Prepared according to S. P. L. Sörensen.

TABLE IV. — *Preparation of Different* $P_{\dot{H}}$ = *(2, 4, 8 and 10).*

Desired $P_{\dot{H}}$	Mixture of Standard Solution.	Coloring Substance.	Indicator.	Number of Cubic Centimeters of n/5 HCl or n/5 NaOH added per 10 c. c. of the Medium.
2, .	3.5 c. c. m/10 citrate and 6.5 c. c. n/10 HCl	4 drops each of tropæolin and methyl violet	5 drops tropæolin 00	3.4 c. c. n/5 HCl
	3 c. c. m/10 citrate and 7 c. c. n/10 HCl	4 drops each of tropæolin and methyl violet	5 drops tropæolin 00	
4, .	5 c. c. m/10 citrate and 5 c. c. n/10 HCl	4 drops each of tropæolin and methyl violet	4 drops methyl red	0.75 c. c. n/5 HCl
	6 c. c. m/10 citrate and 4 c. c. n/10 HCl	4 drops each of tropæolin and methyl violet	4 drops methyl red	
8, .	2 c. c. borate and 8 c. c. boric acid	4 drops each of tropæolin and methyl violet	8 drops naphtolphthalein	0.28 c. c. n/5 NaOH
	3 c. c. borate and 7 c. c. boric acid	4 drops each of tropæolin and methyl violet	8 drops naphtolphthalein	
10, .	6 c. c. borate and 4 c. c. n/10 NaOH	4 drops each of tropæolin and methyl violet	5 drops thymolphthalein	0.6 c. c. n/5 NaOH
	7 c. c. borate and 3 c. c. n/10 NaOH	4 drops each of tropæolin and methyl violet	5 drops thymolphthalein	

Table IV. indicates that 3.4 cubic centimeters of n/5 HCl per 10 cubic centimeters of the medium is necessary to secure $P_{\dot{H}}=2$ approximately; 0.75 cubic centimeters of n/5 HCl for $P_{\dot{H}}=4$; 0.28 cubic centimeters of n/5 NaOH for $P_{\dot{H}}=8$; and 0.6 cubic centimeters n/5 NaOH for $P_{\dot{H}}=10$.

The media, which have been prepared, differ in their total volume; consequently, the concentration of the media differ from each other. Again, the author observed that after subjecting these media to sterilization, on the addition of the required amount of acid and alkali, both $P_{\dot{H}}$ and the amount of formol titrating nitrogen in the media varied widely, as indicated in Table V: —

TABLE V. — *The Influence of Sterilization on $P_{\dot{H}}$ and the Formol Titrating Nitrogen.*

	$P_{\dot{H}}$		FORMOL TITRATING NITROGEN (MG. PER 100 CUBIC CENTIMETERS MEDIUM).	
	Before Sterilization.	After Sterilization.	Before Sterilization.	After Sterilization.
Desired,	found	found	found	found
Control,[1]	6.40	6.55	46.70	47.45
2,	1.80	2.35	47.20	60.50
4,	3.75	4.20	47.15	56.65
8,	8.10	8.45	46.90	51.45
10,	9.85	10.15	47.10	54.30

[1] Medium IV. without addition of acid and alkali.

From Table V. it is evident that a general increase of $P_{\dot{H}}$ took place in each medium, and it is least in the control; the marked and varied increase of the formol titrating nitrogen in each medium occurred and the change is parallel to the amount of the acid and alkali added. These changes may be attributed to the different amounts of acid and alkali added, the heat caused by the sterilization, and the variation in the original concentration.

In order to eliminate these sources of error, and to secure more uniformity in the media, the author resorted to the following procedure: instead of preparing Medium IV. as just stated, it was made up according to the following formula: —

2 per cent. Liebig's meat extract.
2 per cent. Witte's peptone.
1 per cent. NaCl.
1,000 c. c. distilled water.

This medium has been used for the preparation of different $P_{\dot{H}}$, as the formula indicates below.

$\frac{X}{2}$	+	Y	+	$\left(\frac{X}{2} - Y\right)$	=	X
Number of c. c. of the above medium		Required number of c. c. n/5 HCl or n/5 NaOH		Number of c. c. H_2O to make up to the total volume		Total volume

of which

X is the total volume of the medium which has the same constituents as Medium IV.

Y is the required amount of n/5 HCl or n/5 NaOH which has been determined to secure different $P_{\dot{H}}$.

These different constituents were sterilized separately before mixing. The medium which was thus prepared maintains the figured $P_{\dot{H}}$ fairly closely, and also the amount of formol titrating nitrogen becomes uniform, as shown below.

TABLE VI. — *Addition of Acid and Alkali to the Medium, and their Influence upon the Formol Titrating Nitrogen.*

$P_{\dot{H}}$ desired.	$P_{\dot{H}}$ Approximate Colorimetric.	Number of Cubic Centimeters Medium.	Number of Cubic Centimeters n/5 HCl or n/5 NaOH.	Number of Cubic Centimeters H_2O.	Total Volume.	$P_{\dot{H}}$ found Electrometric.	Milligrams of Formol Titrating Nitrogen.
2, . .	2	5	n/5 HCl 3.40	1.60	10	1.357	47.70[1]
4, . .	4	5	0.75	4.25	10	3.559	47.50
8, . .	8	5	n/5 NaOH 0.28	4.72	10	8.245	47.60
10, . .	10	5	0.60	4.40	10	9.788	47.40

[1] Milligrams in 100 cubic centimeters broth.

The results indicate that the two methods, colorimetric and electrometric, give better comparative results where $P_{\dot{H}}$ is greater than 6, or directed toward alkalinity. There is, however, a marked difference when it is directed toward acidity. This may be due to the nature of the indicators used. Again, this last experiment was carried out making the total volume to 10, while the amount of n/5 HCl and n/5 NaOH was determined previously by adding a certain amount of the acid or alkali to 10 cubic centimeters. These factors undoubtedly influenced the results to some extent. In the preparation of the medium used for the proposed investigation, all these factors and precautions have been observed.

Besides these, still another factor has been taken into consideration in carrying out this investigation. The amount of medium added at the time of inoculation may influence the results.

TABLE VII. — *Final Preparation of the Medium of Different* $P_{\dot{H}}$ = *(1–13).*

Desired $P_{\dot{H}}$	Found $P_{\dot{H}}$	Number of					Total.	Milligram F. N. in 100 Cubic Centimeters.
		Cubic Centimeters 2X Medium.	Cubic Centimeters Inoculation.	Cubic Centimeters n/1 HCl.	Cubic Centimeters n/1 NaOH.	Cubic Centimeters H_2O.		
Control, .	5.65	200.0	–	–	–	200.0	400.0	44.80
1, . .	0.86	199.0	1	41.0	–	159.0	400.0	46.20
2, . .	1.86	199.0	1	25.6	–	174.4	400.0	47.60
3, . .	2.62	199.0	1	13.0	–	187.0	400.0	46.20
4, . .	4.18	199.0	1	6.0	–	194.0	400.0	47.60
5, . .	4.82	199.0	1	2.2	–	197.8	400.0	46.20
6, . .	5.42	199.0	1	–	0.5	197.5	400.0	47.20
7, . .	6.66	199.0	1	–	4.0	196.0	400.0	47.60
8, . .	8.17	199.0	1	–	8.0	192.0	400.0	47.60
9, . .	9.43	199.0	1	–	12.0	188.0	400.0	46.20
10, . .	10.47	199.0	1	–	16.0	184.0	400.0	47.60
11, . .	11.22	199.0	1	–	20.0	180.0	400.0	47.60
12, . .	11.60	199.0	1	–	24.0	176.0	400.0	49.00
13, . .	12.80	199.0	1	–	28.0	172.0	400.0	49.00

2X indicates the medium of double concentration.
F.N. indicates the formol titrating nitrogen.

In this preparation n/1 HCl and n/1 NaOH were used instead of n/5 because it appears that the smaller the quantity the easier the manipulation and the greater the accuracy. The results thus obtained are fairly satisfactory.

In flasks 4 and 5 the contents became turbid with the addition of the n/1 acid, while all others remained clear. This turbidity may be due to the precipitation of meta-protein or some other similar substance.

ACCLIMATIZATION OF THE CULTURE.

In general bacteriology it is commonly recognized that environment exerts a great influence upon the physiologic function and morphology of microörganisms. To secure an organism of constant habits the author resorted to the following procedure: —

Six flasks containing 25 cubic centimeters of Medium IV. ($P_{\dot{H}}$ = 6.80) were prepared. One of these was inoculated with *B. subtilis* which was obtained from the American Museum of Natural History, New York. After maintaining this flask at 37° C. for twenty-four hours, subinoculation from it was made into another flask of the same lot as above, by means of a platinum loop. This process of subinoculation was continued from one flask to another every twenty-four hours, until the fifth flask had been inoculated and incubated. From this flask a platinum loopful of the culture was transferred into a dilution flask, which contained 500 cubic centimeters of the same medium. At the same time, three agar plates were made by placing a loopful from the dilution into the first agar tube, and from the first agar tube to the second, and from the second to the third. After these plates had developed for forty-eight hours at 37° C., one entire colony of a medium size was selected and transferred into the sixth flask of the above series by means of a small platinum spatula. This flask had been placed in the incubator for twenty-four hours at 37° C. before using it for inoculation.

Inoculation of Media.

Each of a series of flasks (1 to 13), already prepared and containing 399 cubic centimeters of Medium IV. of various $P_{\dot{H}}$, was inoculated with 1 cubic centimeter of the acclimatized culture. These flasks were then placed in the incubator at 37° C. Waxed paper had been placed over the cotton plug and bound by a rubber band for protection against evaporation. Samples of 50 cubic centimeters for determinations were removed from time to time by means of a sterilized pipette.

RESULTS.

Testing the Vitality of the Organism.

Hydrogen ion concentration has a decidedly inhibitory and lethal influence upon microörganisms; accordingly, a crude test was introduced to follow this. Streak cultures on an agar plate were made at each determination of the hydrogen ion concentration.

Table VIII. — *Test for Vitality.*

Number of Flask.	Original.	24 Hours.	48 Hours.	96 Hours.	144 Hours.	192 Hours.	240 Hours.
Control,	—	—	—	—	—	—	—
1,	—	—	—	—	—	—	—
2,	—	—	—	—	—	—	—
3,	—	—	—	—	—	—	—
4,	—	—	—	—	—	—	—
5,	+	+	+	+	+	+	+
6,	+	+	+	+	+	+	+
7,	+	+	+	+	+	+	+
8,	+	+	+	+	+	+	+
9,	—	—	+	+	+	+	+
10,	—	—	—	—	—	—	—
11,	—	—	—	—	—	—	—
12,	—	—	—	—	—	—	—
13,	—	—	—	—	—	—	—

— no growth.
+ positive growth.

Table VIII. indicates that flasks 5, 6, 7 and 8 proved to be positive from the beginning, while all others were negative, except flask 9, which test gave negative results before forty-eight hours, then became positive. This change may be attributed to inhibitory action.

Determination of the Rate of Growth.

It was found desirable to determine the rate of growth as well as the different hydrogen ion concentrations. This was done by comparing growth turbidity.

Immediately after inoculation, 10 cubic centimeters of the contents of each flask of the set 1 to 13 was transferred into a corresponding set[1] of test tubes of uniform diameter. These test tubes were kept as the standard by the addition of thymol, and protected from evaporation by means of rubber stoppers. At each determination the same amount of a well-mixed sample was transferred from each flask into another set of corresponding test tubes, and the turbidity compared with the standard. The results are here recorded.

Table IX. — *Rate of Growth.*

Number of Flask.	Original.	24 Hours.	48 Hours.	96 Hours.	144 Hours.	192 Hours.	240 Hours.
Control,	—	—	—	—	—	—	—
1,	—	—	—	—	—	—	—
2,	—	—	—	—	—	—	—
3,	—	—	—	—	—	—	—
4,	—	—	—	—	—	—	—
5,	—	+	++	++	+++	+++	+++
6,	—	++	++	+++	+++	+++	+++
7,	—	++	+++	+++	+++	+++	+++
8,	—	+	++	++	+++	+++	+++
9,	—	—	+	+	++	+++	+++
10,	—	—	—	—	—	—	—
11,	—	—	—	—	—	—	—
12,	—	—	—	—	—	—	—
13,	—	—	—	—	—	—	—

— no growth.	++ strong growth.
+ slight growth.	+++ abundant growth.

Table IX. indicates that after twenty-four hours a fairly strong growth took place in flasks 6 and 7, and slight growth in flasks 5 and 8. It was after forty-eight hours that the growth was first observed in flask 9. All other flasks proved to be negative.

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[1] It was necessary to prepare a separate standard for each flask, because flasks 4 and 5 became turbid on addition of acid, as previously stated.

DETERMINATION OF THE RATE OF PROTEOLYSIS.

The rate of proteolysis in media of different hydrogen ion concentration stands as one of the most important phases of this investigation. The method and also an example of such a determination has been treated previously. The results will be given in terms of milligrams per 100 cubic centimeters of the medium (Table X. and Graph 1).

TABLE X. — *Following the Proteolytic Activity.*

NUMBER OF FLASK.	Original.	24 Hours.	48 Hours.	96 Hours.	144 Hours.	192 Hours.	240 Hours.
Control, ...	44.80[1]	46.20	47.60	48.90	49.80	50.20	50.80
1, ...	46.20	49.10	51.80	53.20	53.60	54.20	54.60
2, ...	47.60	50.40	53.20	54.60	56.00	57.40	57.40
3, ...	46.20	51.80	50.40	51.60	53.20	56.00	57.40
4, ...	47.60	46.20	47.60	50.40	53.20	53.20	54.60
5, ...	46.20	50.60	56.00	65.80	82.60	119.00	147.60
6, ...	47.20	54.60	60.20	82.60	117.60	142.80	152.50
7, ...	47.60	56.00	61.60	84.00	113.40	138.60	149.60
8, ...	47.60	49.10	54.00	69.80	89.60	129.40	137.20
9, ...	46.20	47.60	50.90	56.20	62.00	67.20	95.20
10, ...	47.60	49.00	49.00	53.20	57.40	57.60	58.80
11, ...	47.60	49.00	50.40	53.20	53.60	56.00	57.40
12, ...	49.00	50.40	51.80	51.60	57.40	58.80	60.20
13, ...	49.00	50.40	51.80	53.20	60.10	61.60	63.00

[1] Milligrams in 100 cubic centimeters broth.

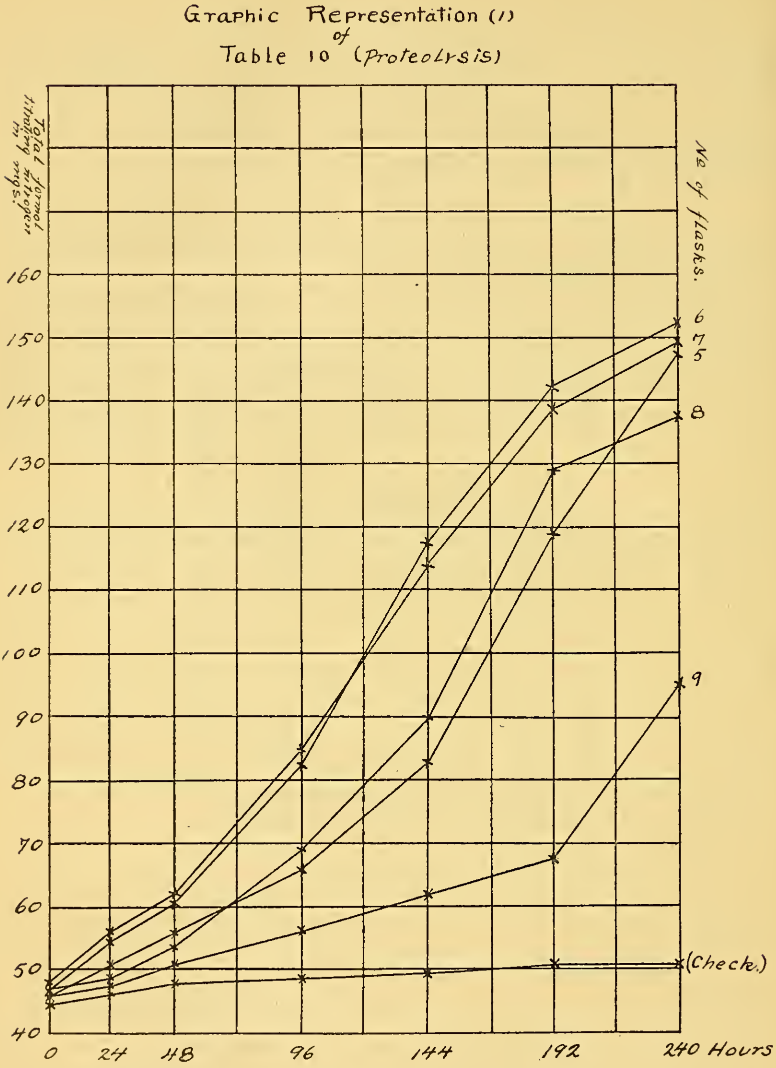

Table X. and Graph 1 indicate the proteolytic activity of *B. subtilis* during two hundred and forty hours' incubation at 37° C. From these results the following deductions may be made: —

1. The proteolysis occurred more or less in all the media including those used as controls. This may be due to hydrolysis brought about by the acid and alkali present, and also by the temperature of the incubator.

2. The greatest activity was manifested in the medium of which the original $P_{\dot{H}}$ was 5.42. In the same medium the rate of proteolysis increased most remarkably after its $P_{\dot{H}}$ was changed to 6.99 or higher.

3. The least proteolytic activity was observed in flask 9, at the end of two hundred and forty hours.

4. The formol titrating nitrogen increased slowly, especially in flasks 5 and 9, up to one hundred and forty-four hours, and then a rapid increase took place. This slow increase at the beginning may be due to the inhibitory reaction of the hydrogen ion concentrations upon the enzymes. After there had been a sufficient amount of protective substance produced the enzyme assumed greater activity.

5. It is probable that the enzyme which brought about the proteolysis in the investigation is tryptic-like in its nature, according to the present conception of the enzymatic classification. The greatest proteolysis took place toward the optimum hydrogen ion concentration, which is $P_{\dot{H}} = 8.076$ in this case. It has been shown that the optimum hydrogen ion concentration for trypsin varies according to the temperature, the materials used and other factors of environment. For instance, Palitzsch and Walbum[1] obtained the following results from their experiment, in which they employed 0.4 per cent. trypsin solution and 6 per cent. gelatin solution.

	TEMPERATURE (DEGREES) C.			
	30.	37.	45.	55.
Optimum $\dot{H}$ ion concentration, .	$10^{-9.9}$	$10^{-9.7}$	$10^{-9.1}$	$10^{-8.0}$

These results indicate that as the temperature increases the optimum point changes toward the neutral point.

Again, Oppenheimer[2] quoted from Mesernitzky's[3] work on *B. prodigiosus*, and stated that the optimum hydrogen ion concentration for the proteolytic action of the organism is slightly less than that of trypsin (10^{-8}).

These references seem to confirm the author's deduction.

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[1] Biochem. Zeitschr., Bd. 47, Heft 1, S. 34.

[2] Oppenheimer, C. Die Fermente u. Ihre Wirkungen, 4 Auflage, Bd. II, S. 617.

[3] Mesernitzky, P. Biochem. Zeitschr., 29, 104, 1910.

Determination of Hydrogen Ion Concentration as Growth progressed.

For this purpose 20, of the 50 cubic centimeters of the medium which had been pipetted out from each flask, were used. The results will be given in terms of $P_{\dot{H}}$.

Table XI. — *Following the Change of Hydrogen Ion Concentration.*

Number of Flask.	Original.	24 Hours.	48 Hours.	96 Hours.	144 Hours.	192 Hours.	240 Hours.
Control,	5.62[1]	5.81	5.93	5.82	5.79	5.78	5.77
1,	0.86	0.85	0.85	0.82	0.81	0.81	0.80
2,	1.86	1.74	1.70	1.68	1.67	1.65	1.62
3,	2.62	2.82	2.75	2.72	2.70	2.60	2.65
4,	4.18	4.13	4.12	4.11	4.08	4.05	4.00
5,	4.82	5.05	5.06	5.48	6.17	7.21	7.89
6,	5.42	5.62	5.83	6.26	6.99	7.87	8.19
7,	6.42	6.66	6.72	6.78	7.48	8.13	8.16
8,	8.17	8.08	7.77	7.58	7.72	8.06	8.13
9,	9.43	9.20	9.00	8.70	8.56	8.01	8.01
10,	10.47	10.25	10.24	10.22	10.18	10.15	10.09
11,	11.22	11.11	11.33	11.29	11.28	11.19	11.22
12,	11.60	11.58	11.45	11.35	11.37	11.35	11.38
13,	12.80	12.95	12.95	12.92	12.90	12.87	12.91

[1] $P_{\dot{H}}$ or exponent of hydrogen ion concentration.

Graphic Representation (2) of Table 11.
(Automatic adjustment of (H) in medium.)

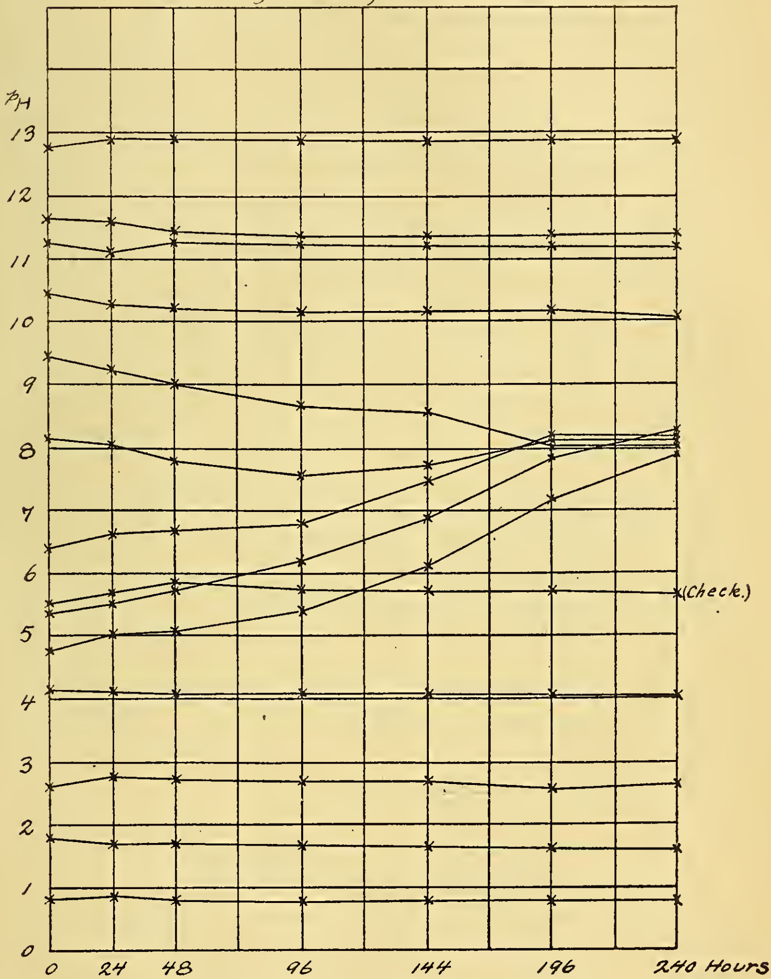

Table XI. and Graph 2 indicate the following $P_{\dot{H}}$ in the media:—

1. Alteration of $P_{\dot{H}}$ in the media occurred within the limit of $P_{\dot{H}}$ 4 to 10 in the course of growth; that is,

$$\left.\begin{array}{l} P_{\dot{H}}=4.82 \text{ changed to } P_{\dot{H}}=7.89 \\ P_{\dot{H}}=5.42 \text{ changed to } P_{\dot{H}}=8.19 \\ P_{\dot{H}}=6.42 \text{ changed to } P_{\dot{H}}=8.16 \\ P_{\dot{H}}=8.17 \text{ changed to } P_{\dot{H}}=8.13 \\ P_{\dot{H}}=9.43 \text{ changed to } P_{\dot{H}}=8.01 \end{array}\right\} \text{ average } P_{\dot{H}}=8.076.$$

On the other hand, in the media where no growth was observed $P_{\dot{H}}$ remained practically constant.

2. Minimum $P_{\dot{H}}$ for *B. subtilis* lies between 4 and 5.
3. Optimum $P_{\dot{H}}$ for *B. subtilis* lies between 7.5 and 8.5.
4. Maximum $P_{\dot{H}}$ for *B. subtilis* lies between 9 and 10.
5. The alteration of $P_{\dot{H}}$ in the media occurred in such a way that different $P_{\dot{H}}$'s were brought toward the optimum $P_{\dot{H}}$. This peculiar alteration of $P_{\dot{H}}$, or so-called "automatic adjustment," is very interesting because it occurred in each of four similar experiments which came under the author's observation. An explanation of this peculiar adjustment remains to be discussed. It was thought by the author that this phenomenon is due to the production of ammonia present as an end-product of proteolysis. This cannot be true, however, because $P_{\dot{H}}$ above the optimum decreased rather than increased; for instance, $P_{\dot{H}} = 9.43$ became $P_{\dot{H}} = 8.01$. Again, it cannot be due to the increased amount of amphoteric substance which has resulted from the growth, because $P_{\dot{H}} = 8.17$ changed only to $P_{\dot{H}} = 8.13$, while other $P_{\dot{H}}$'s were altered markedly, and also against theoretical expectation. It is pertinent to consider the presence of the so-called "protective substance" in enzymatic work in connection with this discussion. In enzymatic work it has been shown by Hudson and Paine[1] and others that cane sugar acts as a protective substance in the case of invertin, especially in the destruction of the enzyme by ethyl alcohol. Recently Chapman[2] demonstrated the relative action of propyl alcohol, methyl acetate and methyl-ethyl ketone upon the invertin, with and without sugar, bringing out strikingly the protective value of cane sugar. It may not be erroneous to consider that in this investigation a protective substance is present or produced in the medium, the action of which may be analogous to that of cane sugar in the case of invertin; that is, the hydrogen ion concentration in the medium is altered by some protective substances bringing it to the optimum concentration for proteolytic enzymatic activity.

DETERMINATION OF CHARACTER OF THE PROTEOLYSIS, VIZ., EREPTIC, PEPTIC AND TRYPTIC IN NATURE.

In the media consisting of different hydrogen ion concentrations, namely $P_{\dot{H}} = 1$ to $P_{\dot{H}} = 13$, which have been described elsewhere, the character of the proteolysis was determined according to the following general principle:[3] if the proteolysis occurs in the media measuring $P_{\dot{H}} = 7$, then it is suggested that this is ereptic; greater than $P_{\dot{H}} = 7$, tryptic; and less than $P_{\dot{H}} = 7$, peptic in nature.

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[1] Jour. Amer. Chem. Soc., V. 32, 1910, 1353.

[2] Internat. Zeitschrift f. Physik.-Chem. Biologie, Bd. I, Heft 5 u. 6, S. 293.

[3] Julius Wohlgemuth. Grundriss der Fermentmethoden, 1913, 135, 182; C. Oppenheimer. Die Fermente u. Ihre Wirkungen, Bd. II, 1913, S. 617; Sven Palitzsch u. L. E. Walbum. Biochem. Zeitschr., Bd. 47, Heft 1, S. 1–35.

Determination of the Endo- or Exo-enzymatic Nature of Enzymes.

Does *B. subtilis* produce endo- or exo-enzyme? To determine this the following procedure was adopted: after *B. subtilis* was cultivated in 500 cubic centimeters of Medium IV. (PḢ = 6.90), at 37° C. for 120 hours, the contents were divided into two equal portions; namely, A and B. Portion A was filtered through a Chamberland porcelain filter[1] under aseptic conditions, and the filtrate, together with portion B (in the original condition), was placed in the incubator at 37° C. for forty-eight hours. At the end of this period the filtrate was carefully examined both macroscopically and microscopically, in order to verify sterility. The filtrate was then taken for inoculation. Three flasks were filled with 400 cubic centimeters Medium IV. (PḢ = 6.90). One of these was kept for control and marked "control;" the second one was marked "1," and inoculated with 1 cubic centimeter of the portion B; and the third was marked "2" and inoculated with 1 cubic centimeter of the filtrate A. These flasks were kept in the incubator and the determinations for PḢ and formol titrating nitrogen were made. The results are indicated on Table XII. and represented in Graph 3.

Table XII. — *Determination of Character of Enzyme.*

	Number of Flask.	Original.	24 Hours.	48 Hours.	96 Hours.	144 Hours.	192 Hours.	240 Hours.
PḢ	Control, . .	6.90	6.88	6.80	6.85	6.85	6.90	7.00
	1, ...	7.11	7.18	7.20	7.30	7.60	7.90	8.10
	2, ...	6.99	7.00	7.05	7.10	7.13	7.20	7.20
F. N.	Control, . .	46.00[2]	46.40	47.50	49.00	49.50	50.00	51.00
	1, ...	49.00	55.00	61.50	91.00	121.50	140.50	146.00
	2, ...	48.10	49.00	50.50	52.00	53.00	55.00	57.00

F. N. — formol titrating nitrogen.

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[1] Zak. Hofm. Beitr., 10, 287, 1907; Schmailowitsch, F. Zbl. Biochem., I, 467; de Waele, H. Zbl. Bakt., 50, 40, 1909.

[2] Milligrams in 100 cubic centimeter medium.

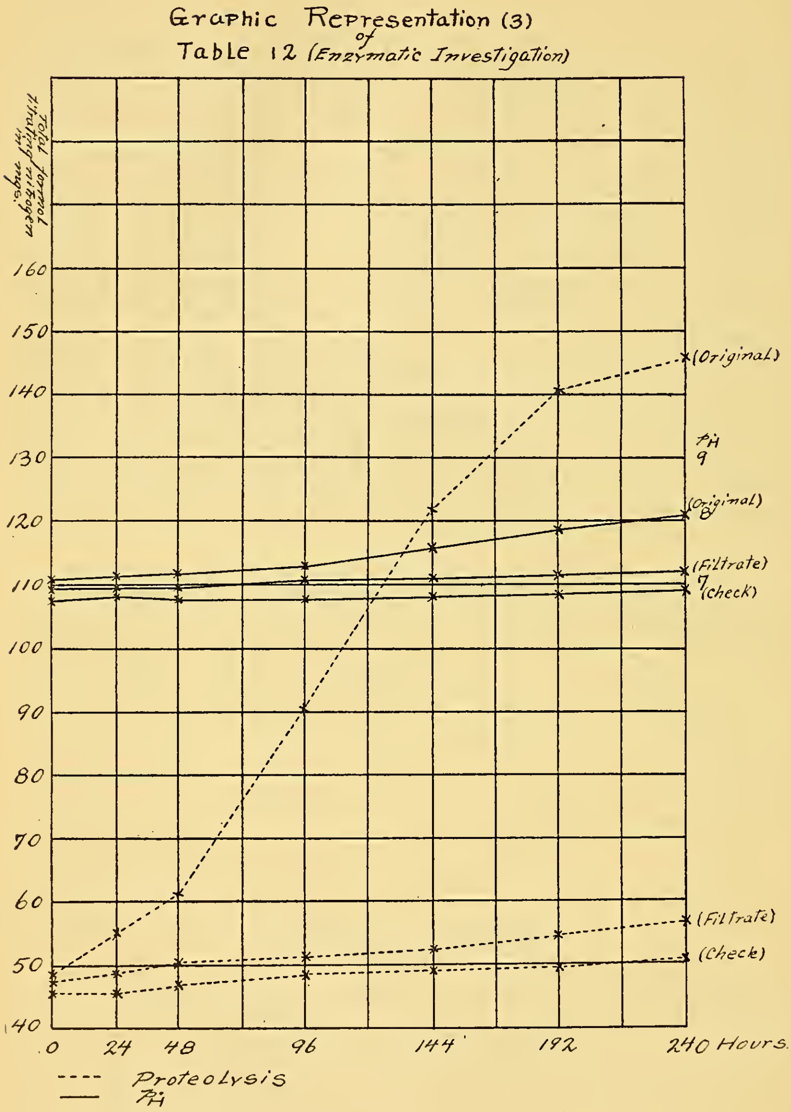

Table XII. and Graph 3 indicate the following: —

1. PḢ in flask 1 increased toward the optimum PḢ or, changed from PḢ = 7.11 to PḢ = 8.10, while PḢ in the control and flask 2 increased very slightly.

2. The amount of formol titrating nitrogen in flask 1 increased from 49 to 146 milligrams, while in the others the increase was very slight.

From these results it may be said that *B. subtilis* produces endo-enzyme and no exo-enzyme. The author may not, however, be justified in applying the term "enzyme" in this connection, because the proteolysis which took place in flask 1 might have been brought about by any one of the following agents: —

1. Enzyme.
2. Direct action of the living protoplasm.
3. Enzyme and the living protoplasm.

The distinction between these factors, in the light of present knowledge, is not easily made, although the matter has been investigated by some workers. For instance, Gotschlich[1] would distinguish between the action of enzyme and the living protoplasm as follows: "Fermentation is a direct function of the living protoplasm, and serves as its source of energy," while "enzyme action is not directly dependent on the living protoplasm, and does not serve the organism as a source of energy." In order to demonstrate these statements there are several methods; for example, the use of antiseptics which kill the causal organisms but do not measurably impair the enzyme. Kaufmann[2] has shown that very dilute enzymes are nearly as susceptible to antiseptics as are bacteria. Thus it may be understood that the distinction between these factors is not easily made. The author has taken the liberty to designate these causal substances in this investigation as enzymes, and has distinguished endo- and exo-enzymes according to the method employed.

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[1] Kolle u. Wassermann's Handbuch, V. 1, 104.

[2] Zeit. Physiol. Chem., 1903 (39), 434.

PART II.

PROTEOLYSIS OF STREPTOCOCCUS ERYSIPELATIS AND STREPTOCOCCUS LACTICUS COMPARED UNDER DIFFERENT HYDROGEN ION CONCENTRATION.

INTRODUCTION.

As intimated previously, the methods of proteolysis under different hydrogen ion concentrations as described, might furnish a means for assisting in differentiating closely related organisms. An application is here attempted with *Streptococcus erysipelatis* and *Streptococcus lacticus.* The significance of streptococci in market milk, and the indiscriminate practice of attributing many afflictions to them, have led to this choice of organisms, for it involves the so-called virulent and avirulent strains of streptococci. Heinemann[1] and others have demonstrated that *Streptococcus lacticus* is very closely related to *Streptococcus pyogenes,* not only morphologically and culturally, but also in pathogenicity.

GENERAL METHODS OF PROCEDURE.

ORGANISMS EMPLOYED IN THE INVESTIGATION.

(*a*) *Streptococcus Erysipelatis* (*Streptococcus* "*E* ").

Furnished by H. K. Mulford Company, Philadelphia. Virulent for rabbit, Guaranty No. 172.

(*b*) *Streptococcus Lacticus.*

Isolated by the author from starter at this institution and found to be avirulent for rabbit.

MEDIUM.

Composition: —

500 gms. chopped lean beef[2] 1 per cent. Witte's peptone 0.5 per cent. NaCl	per 1,000 c. c. of water.

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[1] Heinemann, P. G. Jour. Infect. Diseases, 4, No. 1, 89, Jan., 1907.

[2] Chopped lean beef, rather than Liebig's meat extract, was found to be favorable for this investigation.

First, 2,500 cubic centimeters double-strength bouillon of the above composition was prepared as follows: 2,500 grams chopped lean beef was placed in 2,500 cubic centimeters distilled water for twenty-four hours at 15° C. (this infusion was strained through two layers of cheesecloth); 50 grams Witte's peptone and 25 grams NaCl were mixed together in a smooth paste, with 500 cubic centimeters of the strained infusion. Care must be exercised to leave no unbroken globular masses of peptone. Add the peptone emulsion to the rest of the infusion and make up to the required volume. Autoclave fifteen minutes under 15 pounds' pressure. Adjust the reaction to very faint pink for phenolphthalein by the addition of n/1 NaOH;[1] then autoclave for forty-five minutes, and filter through Swedish filter paper. Control the volume. Place 200 cubic centimeters of the bouillon thus prepared into each of eleven Erlenmeyer flasks (500 cubic centimeters) and sterilize in the autoclave for thirty minutes. The remaining portion may be employed to estimate the hydrogen ion concentration as previously described; that is, at first an approximate reaction is determined by the colorimetric method,[2] then finally electrically.[3] The following table indicates the various amount of n/1 NaOH or n/1 HCl and distilled water (sterilized) to be added separately[4] to obtain the different hydrogen ion concentrations desired: —

TABLE I. — *Preparation of Media.*

	Desired P_H	Found P_H	Number of —					Total Volume.
			Cubic Centimeter 2X Broth.	Cubic Centimeter Inoculation.	Cubic Centimeter n/1 HCl.	Cubic Centimeter n/1 NaOH.	Cubic Centimeter H_2O.	
Set 1.	Control,	7.60	200.0	–	–	–	200.0	400.0
	5.5,[5]	4.79	199.0	1	8	–	192.0	400.0
	6.5,	6.35	199.0	1	4	–	196.0	400.0
	7.5,	7.65	199.0	1	–	–	200.0	400.0
	8.5,	8.76	199.0	1	–	4	196.0	400.0
	9.5,	9.55	199.0	1	–	8	192.0	400.0
Set 2.	5.5,[5]	4.80	199.0	1	8	–	192.0	400.0
	6.5,	6.45	199.0	1	4	–	196.0	400.0
	7.5,	7.62	199.0	1	–	–	200.0	400.0
	8.5,	8.85	199.0	1	–	4	196.0	400.0
	9.5,	9.63	199.0	1	–	8	192.0	400.0

Sets 1 and 2 were prepared at the same time.

P_H — exponent of hydrogen ion concentration, explained previously.

Inoculation was made with 1 cubic centimeter of forty-eight hour lactose broth culture.

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[1] This manipulation is found to be necessary in order to have the bouillon remain clear.

[2] It has been described previously on p. 161.

[3] It has been described previously on p. 145.

[4] It has been described previously on p. 163.

[5] This has been treated on p. 161.

After the hydrogen ion concentration has been adjusted the flasks are placed in an incubator at 37° C. for twenty-four hours, to establish their sterility as well as to maintain the medium at this temperature. After this period 1 cubic centimeter of a forty-eight-hour lactose broth culture of each, *Streptococcus erysipelatis* and *Streptococcus lacticus*, was used to inoculate Set 1 and Set 2, respectively. Observations of rate of growth, hydrogen ion concentration and proteolysis were made at the various intervals as indicated in tables.

RATE OF GROWTH.

It seemed essential to determine the rate of growth in connection with the other factors. This was done macroscopically, by taking a degree of turbidity[1] as an indicator. The results are recorded in Table 2.

TABLE 2. — *Rate of Growth.*

NUMBER OF FLASK.		TIME IN HOURS.						
		6.	12.	18.	24.	48.	72.	120.
Set 1.	Control,	—	—	—	—	—	—	—
	5,	—	—	—	—	—	—	—
	6,	+	+	+	++	++	++	++
	7,	++	+++	+++	+++	+++	+++	+++
	8,	+	++	++	++	++	+++	+++
	9,	—	+	+	++	++	++	+++
Set 2.	5,	—	—	—	+	+	++	++
	6,	—	—	+	+	++	++	++
	7,	—	—	+	+	++	++	++
	8,	—	—	+	+	+	+	++
	9,	—	—	—	—	—	—	—

— none. + slight. ++ moderate. +++ abundant.
Set 1 — *Streptococcus erysipelatis.*
Set 2 — *Streptococcus lacticus.*

This table indicates that *Streptococcus erysipelatis* grows best in the medium of which the hydrogen ion concentration is 2.24×10^{-8} or optimum; the growth becomes slower as the hydrogen ion concentration decreases; an increase of the hydrogen ion concentration seems to have some deleterious influence upon the growth, viz., $(\dot{H}) = 1.59 \times 10^{-5}$ has lethal influence. On the other hand, *Streptococcus lacticus* grows very slowly in all the media except $(\dot{H}) = 2.35 \times 10^{-10}$. This is interesting to note because it suggests stimulation by preceding environmental conditions. *Streptococcus erysipelatis* has existed in the medium of an animal body of which the reaction of blood is approximately $P_{\dot{H}}=7.56$ or $(\dot{H})=2.75\times10^{-8}$;[1] on the other hand, *Streptococcus lacticus* existed previous to the isolation in the starter of which the reaction is about $P_{\dot{H}}=5$ or $(\dot{H})=1\times10^{-5}$.[2] Considering these facts with the results obtained, the correlation between the degree of growth in the medium of different hydrogen ion concentration and their previous surroundings is indicated.

---

[1] This has been described in the previous work.

RATE OF PROTEOLYSIS.[3]

TABLE 3. — *Proteolysis.*

	NUMBER OF FLASK.	TIME IN HOURS.							
		Original.	6.	12.	18.	24.	48.	72.	120.
Set 1.	Control,	40.10[4]	40.25	40.30	40.50	40.50	40.80	41.00	41.20
	5,	42.00	42.60	43.80	42.00	44.00	44.40	44.20	44.80
	6,	42.00	44.80	53.20	57.40	58.00	60.80	61.20	63.70
	7,	43.40	47.60	57.40	60.20	60.80	68.60	74.20	77.00
	8,	40.00	46.20	51.80	54.60	57.40	60.80	65.80	68.60
	9,	42.50	44.80	50.40	53.20	54.60	57.40	57.40	60.80
Set 2.	5,	43.40	43.40	44.80	44.80	43.40	44.80	44.80	44.90
	6,	39.20	42.00	43.40	43.40	46.20	47.00	49.10	55.00
	7,	42.00	42.40	43.40	47.60	49.00	50.20	51.60	53.50
	8,	40.60	41.00	40.60	43.40	46.20	47.20	49.10	49.80
	9,	40.60	42.00	42.50	43.50	43.40	44.80	43.40	44.80

Set 1 — *Streptococcus erysipelatis.*
Set 2 — *Streptococcus lacticus.*

Table 3 indicates the following: —

Set 1 (*Streptococcus erysipelatis*). — The greatest proteolysis occurred in flask 7, and practically no proteolysis in flask 5; at the end of six hours proteolysis appeared.

Set 2 (*Streptococcus lacticus*). — The greatest proteolytic activity was manifested in flask 6 and practically none in flask 9; it was not until the end of eighteen hours that slight proteolysis began to appear.

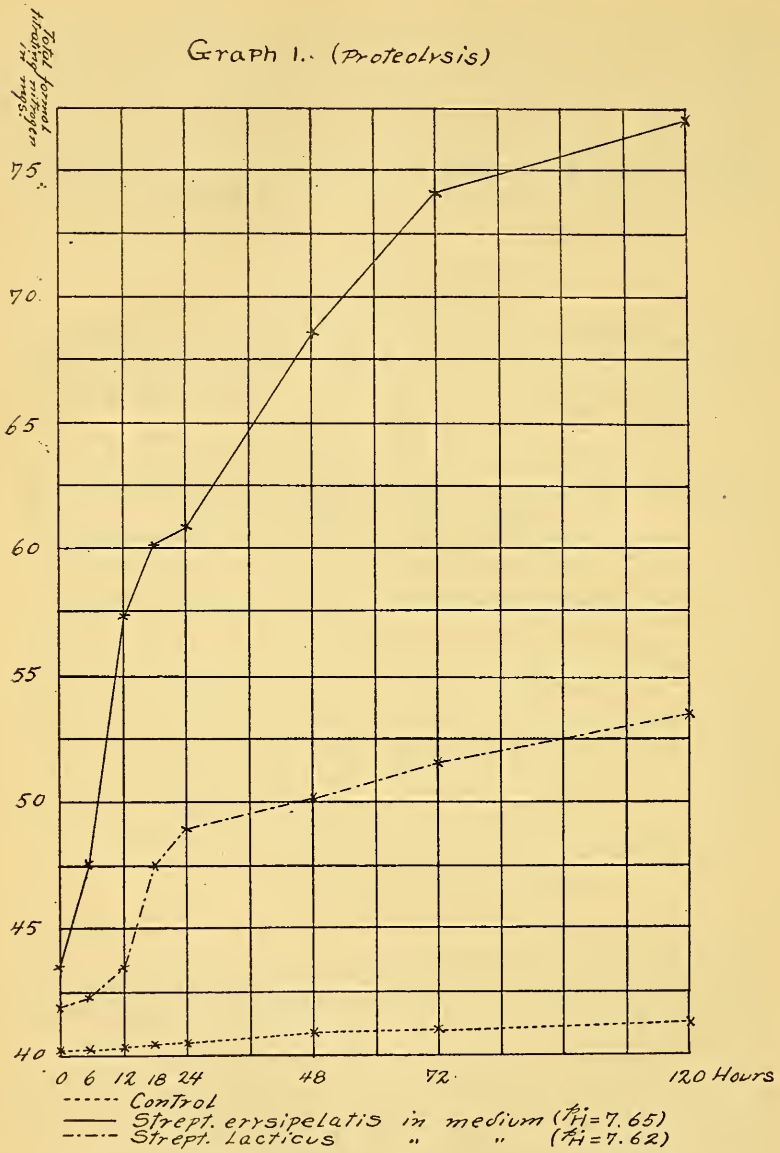
---

[1] Michaelis, L. Die Wasserstoffionenkonzentration, Berlin, 101, 1914.

[2] $(\dot{H})$ of starter from which the organism was isolated.

[3] The method for determination has been described previously.

[4] Milligrams per 100 cubic centimeters.



Graph 1 represents the proteolysis of *Streptococcus erysipelatis* and *Streptococcus lacticus* in the media of which the hydrogen ion concentration is $(\dot{H}) = 2.24 \times 10^{-8}$ and $(\dot{H}) = 2.40 \times 10^{-8}$, respectively. The results in these two media (the same within the limit of error) were especially considered instead of the optimum hydrogen ion concentration for proteolysis in the case of each organism. The reason for this is to be found in an effort to comply with the purpose of this investigation.

From these results the following deductions may be made: —

A difference in the degree and also the rate of proteolysis between *Streptococcus erysipelatis* and *Streptococcus lacticus* is shown.

Again, it seems to suggest a correlation between the proteolysis, also, and the preceding environmental factors as stated under "Rate of Growth." *Streptococcus erysipelatis* existing in the animal body rich in body proteins with only a slight amount of carbohydrate present and at 37° C., with *Streptococcus lacticus* existing in a medium of abundant carbohydrates as well as protein substances and at 20° C. or less, must be influenced by their former habitats.

According to this stimulation, generally recognized by physiologists, *Streptococcus erysipelatis* would naturally give rise to abundant proteolytic enzymes, while *Streptococcus lacticus* would produce enzymes acting on carbohydrate (lactose). Such a case seems to be indicated in the present work.

DETERMINATION OF HYDROGEN ION CONCENTRATION AS GROWTH PROGRESSED.[1]

TABLE 4. — *P$_{\dot{H}}$ in Media.*

	Number of Flask.	Time in Hours.							
		Original.	6.	12.	18.	24.	48.	72.	120.
Set 1.	Control,	7.60	7.65	7.63	7.68	7.66	7.60	7.65	7.80
	5,	4.79	4.85	4.80	4.89	4.88	4.75	4.80	4.90
	6,	6.35	6.43	6.65	6.78	6.90	7.00	7.20	7.40
	7,	7.65	7.70	7.80	7.85	7.80	7.75	7.70	7.65
	8,	8.76	8.50	8.30	8.20	7.90	7.80	7.85	7.60
	9,	9.55	9.30	9.20	9.05	8.80	8.75	8.60	8.20
Set 2.	5,	4.80	4.85	4.90	4.85	4.75	4.70	4.75	4.75
	6,	6.45	6.53	6.60	6.65	6.70	6.85	6.90	7.10
	7,	7.62	7.65	7.68	7.70	7.66	7.74	7.70	7.60
	8,	8.85	8.70	8.60	8.55	8.50	8.40	8.35	8.20
	9,	9.63	9.55	9.53	9.53	9.50	9.60	9.55	9.65

Set 1 — *Streptococcus erysipelatis.*
Set 2 — *Streptococcus lacticus.*

Table 5 indicates the occurrence of an adjustment (automatic adjustment)[2] of the hydrogen ion concentration in the media. Attention was called to this phenomenon and its probable explanation given in the previous work.[3]

---

[1] This has been explained previously.

[2] See p. 172.

[3] See p. 174.

SUMMARY AND CONCLUSIONS.

Part I.

1. The determination of "true reaction" in such a bacteriologic culture medium as was used in the investigation can be made successfully by means of the hydrogen electrode.

2. Sörensen's formol titration method gives very satisfactory results in determining the rate of proteolysis.

3. Medium IV. seems very suitable for the determination of hydrogen ion concentration and proteolysis in the case of *B. subtilis.* In order to secure a fixed chemical and physical factor it is advisable to boil it for an hour or place it in an autoclave for thirty minutes or longer, under 15 pounds' pressure.

4. The desired hydrogen ion concentration in the medium is obtained by the aid of the colorimetric method, avoiding sterilization after the addition of acid or alkali.

5. $P_{\dot{H}} = 9.43$ seems to have an inhibitory action upon *B. subtilis,* while $P_{\dot{H}}$'s below 4.18 and above 9.43 have a germicidal effect.

6. The minimum, optimum and maximum $P_{\dot{H}}$ for *B. subtilis* are as follows: —

Minimum, between $P_{\dot{H}} = 4$ and $P_{\dot{H}} = 5$.
Optimum, between $P_{\dot{H}} = 7.5$ and $P_{\dot{H}} = 8.5$.
Maximum, between $P_{\dot{H}} = 9$ and $P_{\dot{H}} = 10$.

7. An alteration of the hydrogen ion concentration in the medium by *B. subtilis* occurred between $P_{\dot{H}} = 4.18$ and $P_{\dot{H}} = 9.43$.

8. *B. subtilis* produced a tryptic-like enzyme which is endo-cellular.

From the foregoing summary the relation between the hydrogen ion concentration in the medium and the proteolytic activity of *B. subtilis* may be concluded as follows: certain hydrogen ion concentrations measure the exact influence both inhibitory and prohibitory, and indicate the exact limits of the proteolytic activity of *B. subtilis.* Further, the hydrogen ion concentrations of the medium converged toward the optimum as proteolysis proceeded.

Part II.

1. *Streptococcus erysipelatis,* the virulent strain, multiplied much more rapidly in the broth than *Streptococcus lacticus,* the nonvirulent strain.

2. A difference both in degree and rate of proteolysis is evident; *Streptococcus erysipelatis* is much more active and vigorous than *Streptococcus lacticus.*

3. The optimum hydrogen ion concentration for proteolysis differs, as follows: —

$P_{\dot{H}} = 7.62$ or $(\dot{H}) = 2.40 \times 10^{-8}$ for *Streptococcus erysipelatis.*
$P_{\dot{H}} = 7.02$ or $(\dot{H}) = 9.55 \times 10^{-8}$ for *Streptococcus lacticus.*

4. Alteration of the hydrogen ion concentrations toward the optimum occurred during the course of proteolysis.

These results for *Streptococcus erysipelatis* and *Streptococcus lacticus* point to a very close relationship between the optimum hydrogen ion concentration for proteolysis (in the bouillon) and the hydrogen ion concentration of their natural environmental conditions (blood and milk, respectively).

So far as this investigation is concerned, the differentiation of *Streptococcus erysipelatis* and *Streptococcus lacticus*, virulent and avirulent streptococci, through their proteolytic activity in conjunction with certain hydrogen ion concentration in culture medium, seems to be promising, although further data are desired before its generalization may be realized.

In connection with this investigation, the author's gratitude is due to Prof. S. P. L. Sörensen, Prof. A. Klöcker, Dr. H. Jessen-Hansen and Dr. Sven Palitzsch, of the Carlsberg Laboratory, Copenhagen, Denmark; to Prof. A. Hopkins of Amherst College; to Prof. J. S. Chamberlain and Prof. F. H. H. van Suchtelen of this institution; especially to Prof. C. E. Marshall, under whom the work of this thesis has been concluded.

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